FEBRUARY 1950

Journal

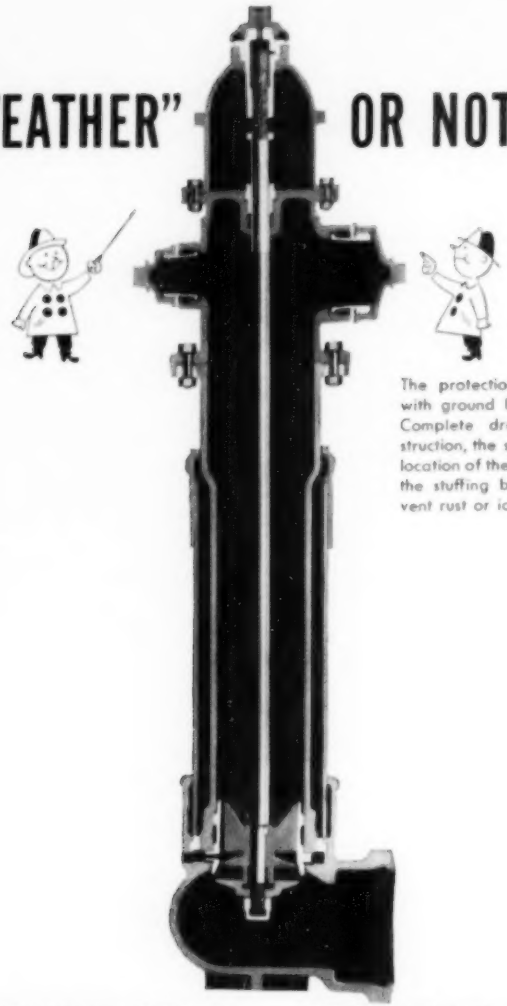
VOL. 42 • NO. 2

AMERICAN WATER WORKS ASSOCIATION

In this issue

Consulting Services	Niles, Heffelfinger
Maryland Sanitary Districts	Pasarew, Smith, Kaltenbach
Public Authorities in Pennsylvania	Hoffert
Radioactive Wastes	Placak, Morton
Diversion of Water Works Funds	Gotherman
Pennsylvania Clean-Streams Program	Moses
Chlorine Dioxide	Aston
Coliform Incubation Temperature	Boniece, Mallmann
Methemoglobinemia	Bosch et al.
Well Redevelopment by Explosives	Ebaugh
Infiltration Gallery at Ontonagon	Francis
Long-Line Design and Location	Trahern, Lauenstein
Liquid Carbon Dioxide	Mellen
History of Water Supply in Russia	A Book Review

"WEATHER" OR NOT



The protection case is free to move with ground heaves caused by frost. Complete drainage, leakproof construction, the shield operating nut, and location of the operating thread above the stuffing box, all combine to prevent rust or ice from forming.

MATHEWS HYDRANTS

THE FIREMAN'S FRIEND

Made by R. D. Wood Company
Public Ledger Building, Independence Square
Philadelphia 5, Pa.
Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

Mathews Modernized Hydrants Set the Pace: Easily maintained, because simple in construction • All working parts contained in replaceable barrel • Stuffing box cast integral with nozzle section • Head can be turned 360° • Replaceable head • Nozzle sections easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • Operating thread only part to be lubricated • A modern barrel makes an old Mathews good as new

...only

LOCK JOINT

offers all 8 of these advantages

Each of these characteristics is essential to a good water supply line, and Lock Joint Reinforced Concrete Pressure Pipe alone offers ALL 8 OF THESE ESSENTIAL QUALITIES.

1. Life Expectancy of over 100 Years
2. Freedom from Corrosion, Tuberculation and Electrolysis
3. Permanent High Carrying Capacity
4. Freedom from Rupture, Blow-out or Collapse
5. Ability to Withstand Extreme Beam and Back Loads
6. Designed to Any Pressure Common to American Water Works Practice
7. Low Initial Cost and Minimum Maintenance Charges
8. Expansion Joints Installed with Maximum Ease and Economy

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

Pressure Pipe Plants: Wharton, N. J. • Turner, Kans.

BRANCH OFFICES: Cheyenne, Wyo. • Denver, Colo. • Kansas City, Mo. • Valley Park, Mo. Chicago, Ill. • Rock Island, Ill. • Wichita, Kan. Kenilworth, N. J. • Hartford, Conn.

SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE

AMERICAN WATER WORKS ASSOCIATION
INCORPORATED

500 Fifth Avenue, New York 18, N.Y.
(Telephone: LAckawanna 4-2290)

A. P. BLACK, Head, Dept. of Chemistry, Univ. of Florida, Gainesville, Fla. *President*
W. VICTOR WEIR *Vice-President*
WILLIAM W. BRUSH *Treasurer*
HARRY E. JORDAN (*Residence phone:* POrt Washington 7-2441) *Secretary*
ERIC F. JOHNSON *Asst. Secretary*

Board of Directors

Alabama-Mississippi Sec.	A. CLINTON DECKER, Birmingham, Ala.	to 1950
Arizona Section	ALDEN W. MILLER, Phoenix, Ariz.	–1950
California Section	CARL M. HOSKINSON, Sacramento, Calif.	–1951
Canadian Section	W. E. MACDONALD, Ottawa, Ont.	–1952
Chesapeake Section	HARRY B. SHAW, Hyattsville, Md.	–1951
Cuban Section	LEANDRO DE GOICOECHEA, Havana, Cuba	–1951
Florida Section	DAVID B. LEE, Jacksonville, Fla.	–1951
Illinois Section	CLIFFORD FORE, Mt. Vernon, Ill.	–1951
Indiana Section	EDWARD F. KINNEY, Indianapolis, Ind.	–1952
Iowa Section	H. F. BLOMQUIST, Cedar Rapids, Iowa	–1952
Kansas Section	MAJOR C. HAGAR, Lawrence, Kan.	–1952
Kentucky-Tennessee Sec.	C. M. MCCORD, Memphis, Tenn.	–1950
Michigan Section	RENE J. LA MARRE, Adrian, Mich.	–1950
Minnesota Section	D. B. MORRIS, St. Paul, Minn.	–1951
Missouri Section	M. P. HATCHER, Kansas City, Mo.	–1952
Montana Section	JOHN W. HALL, Fort Shaw, Mont.	–1951
Nebraska Section	JOHN C. DETWEILER, Omaha, Neb.	–1950
New England Section	P. A. SHAW, Manchester, N.H.	–1950
New Jersey Section	CHARLES H. CAPEN, Wanaque, N.J.	–1950
New York Section	WALLACE T. MILLER, Ossining, N.Y.	–1950
North Carolina Section	GEORGE S. MOORE, Albemarle, N.C.	–1952
Ohio Section	L. T. FAWCETT, Youngstown, Ohio	–1951
Pacific Northwest Sec.	WALTER J. MOORE, Eugene, Ore.	–1950
Pennsylvania Section	MYRON G. MANSFIELD, Pittsburgh, Pa	–1950
Rocky Mountain Section	DANA E. KEPNER, Denver, Colo.	–1952
Southeastern Section	N. M. DEJARNETTE, Atlanta, Ga.	
Southwest Section	M. B. CUNNINGHAM, Oklahoma City, Okla.	–1951
Virginia Section	H. E. LORDLEY, Richmond, Va.	–1952
West Virginia Section	T. J. BLAIR JR., Charleston, W.Va.	–1952
Wisconsin Section	WILLIAM U. GALLAHER, Appleton, Wis.	–1952
Manufacturer	DANIEL J. SAUNDERS, New York, N.Y.	–1952
Manufacturer	WILLARD F. ROCKWELL, Pittsburgh, Pa.	–1950
Manufacturer	WILLIAM J. ORCHARD, Newark, N.J.	–1951

Ex-Officio Members of the Board

President	A. P. BLACK, Gainesville, Fla.	–1951
Past-President	LINN H. ENSLOW, New York, N.Y.	–1950
Vice-President	W. VICTOR WEIR, University City, Mo.	–1950
Treasurer	WILLIAM W. BRUSH, New York, N.Y.	–1950
Ch. W. W. Practice Com.	LOUIS R. HOWSON, Chicago, Ill.	–1950
Ch. W. W. Admin. Com.	WENDELL R. LADUE, Akron, Ohio	–1950
Ch. Publication Com.	CHARLES H. CAPEN, Wanaque, N.J.	–1950

Journal A.W.W.A. is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 500 Fifth Ave., New York 18, N. Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in Sec. 1103, Act of Oct. 3, 1917; authorized Aug. 6, 1918.

Copyright, 1950, by the American Water Works Association, Inc.

Made in United States of America

Why TRIDENT Meters COST LESS and GIVE YOU THE MOST REVENUE!

② THE GEAR TRAIN

FORMULA:

DESIGN + MATERIALS + PRODUCTION

DESIGN . . . . . Oil-enlosed • Simple • Rugged

MATERIALS . . . . . Selected materials •

PRODUCTION . . . . . Accurate machining • Close inspection

RESULTS:

- Feather-touch sensitivity
- Elimination of wear and corrosion
- Long life

YOU can't beat Trident Meters for maximum revenue and minimum maintenance cost. In design, materials and production, they are made specifically to produce these results. Trident Meters will run accurately for years—will remain in profitable operation long after their purchase-bonds have been retired.

213

New improved parts in old Trident Meter

NEPTUNE METER COMPANY • 50 West 50th Street • NEW YORK 20, N.Y.

Branch Offices in Chicago, San Francisco, Los Angeles, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.

NEPTUNE METERS, LTD., Long Branch, Ont., Canada

DIVISION AND SECTION OFFICERS

Officers of the Divisions

Water Purification Division—Chairman, J. E. KERSLAKE; Vice-Chairman, H. E. LORDLEY; Secretary-Treasurer, R. L. DERBY; Directors, M. E. FLENTJE, H. O. HARTUNG, I. M. GLACE.

Water Resources Division—Chairman, L. W. GRAYSON; Vice-Chairman, H. E. HUDSON, JR.; Secretary-Treasurer, G. E. FERGUSON; Directors, RICHARD HAZEN, D. D. GROSS.

Water Works Management Division—Chairman, G. E. ARNOLD; Vice-Chairman, L. J. HOFFMAN; Secretary-Treasurer, PAUL WEIR; Directors, J. L. HAWKINS, M. B. CUNNINGHAM.

Officers of the Sections

*Section**	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*	*Past-Chairman*
Alabama-Miss.	G. H. Godwin	T. H. Allen	J. L. Snow	B. F. Wade
Arizona	A. A. Frederickson	G. W. Marx	Mrs. H. Rotthaus	J. F. Rauscher
California	E. A. Reinke	G. E. Arnold	W. W. Aultman	L. W. Grayson
Canadian	N. MacNicol		A. E. Berry	R. H. Martindale
Chesapeake	C. Gardner	D. Auld	C. J. Lauter	E. A. Schmitt
Cuban	M. J. Puente	L. Radelat	L. H. Daniel	L. A. Nunez
Florida	S. K. Keller	S. W. Wells	A. E. Williamson	W. W. Gillespie
Illinois	J. C. Moomau	W. R. Gelston	C. N. Brown	H. R. Frye
Indiana	M. P. Crabill	J. Gordon	C. H. Bechert	C. E. Williams
Iowa	G. Nelson	M. E. Driftmier	H. V. Pedersen	R. O. Ellis
Kansas	A. B. Mawdsley	A. W. Rumsey	H. W. Badley	H. H. Kansteiner
Kentucky-Tenn.	R. W. Williamson	J. W. McCoy	R. P. Farrell	Miss L. Sutherland
Michigan	J. E. Cooper	G. Hazey	T. L. Vander Velde	J. F. Dye
Minnesota	A. F. Mellen	H. Lundquist	R. M. Finch	H. G. Tischer
Missouri	R. E. Piner	C. E. Schanze	W. A. Kramer	J. F. Sanders
Montana	M. F. Dixon	M. E. Henderson	C. W. Brinck	J. B. Hazen
Nebraska	V. Livingston	C. W. Burdick	J. W. Cramer	G. E. Bell
New England	W. A. Gentner	D. C. Calderwood	R. H. Ellis	W. B. Duffy
New Jersey	R. E. Bonyun	A. Shinn	C. B. Tygert	P. S. Wilson
New York	L. B. Smith	A. T. Luce	R. K. Blanchard	J. M. Wardle
North Carolina	E. R. Tull	W. W. Adkins	E. C. Hubbard	R. W. Luther
Ohio	A. A. Ullrich	A. S. Hibbs	F. P. Fischer	T. R. Lathrop
Pacific Northwest	B. C. Gosney	E. James	O. P. Newman	J. E. Morrison
Pennsylvania	E. C. Goehring	T. H. Kain	L. S. Morgan	E. J. Taylor
Rocky Mountain	B. V. Howe	C. G. Caldwell	G. J. Turre	H. M. Krull
Southeastern	J. F. Pearson	S. Russell	T. A. Kolb	T. A. Jones
Southwest	J. R. Pierce	K. F. Hoefle	L. A. Jackson	D. W. Robinson
Virginia	E. C. Meredith	R. D. Wright	W. H. Shewbridge	H. E. Silcox
West Virginia	M. K. Jones	W. S. Staub	J. B. Harrington	J. A. Sample
Wisconsin	T. M. McGuire	F. K. Quimby	L. A. Smith	J. A. Snow

* For Section's representative on the A.W.W.A. Board of Directors, see list on page ii.

What can research do for a specification product?

We manufacture a "specification" product—cast iron pressure pipe. It is purchased under standard specifications set up by engineering organizations representing users of the product, consultants and manufacturers. Meet the specifications and the customer is satisfied. The question is whether the manufacturer should be satisfied.

About 20 years ago we decided to find out what research could do for a "specification" product. The function of Industrial Research was then, as it is now, to develop a better product at the same, or if possible, at lower cost. We built and equipped a Research Laboratory.

What research has since done for our product is a result best known to our customers! After all, specifications only establish a "floor" beneath which quality standards must not fall. Through research we have steadily elevated those standards and, through quality control, have seen to it that they are adhered to.

Progress made by individual companies eventually leads to higher standards which must be met by all makers of the product. And progress in the production of cast iron pressure pipe is important to water, gas and sanitation utilities as well as to the public they serve. The key to such progress is Research.

To further our Research program we recently dedicated a new, even larger and finer research laboratory and developmental foundry at our plant and main office in Burlington, New Jersey.

U. S. Pipe & Foundry Co., General Offices, Burlington, N. J. *America's largest producer of cast iron pressure pipe.*

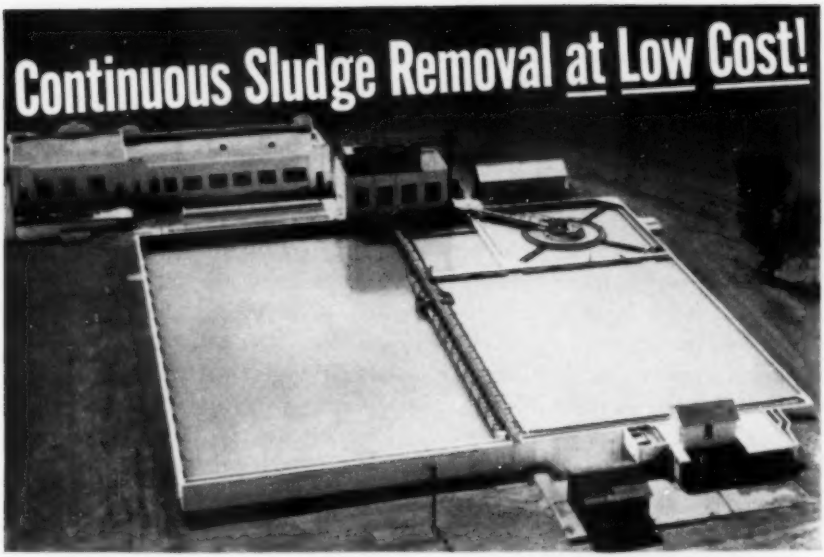
LIST OF ADVERTISERS

Aluminum Co. of America, Chemicals Div. ... 63
American Brass Co., The ... —
American Cast Iron Pipe Co. ... —
American Cyanamid Co., Industrial Chemicals Div. ... —
American Norit Co., Inc. ... —
American Pipe & Construction Co. ... 51
American Well Works ... —
Anthracite Equipment Corp. ... —
Armco Drainage & Metal Products, Inc. 69
Art Concrete Works ... —
Atlas Mineral Products Co., The ... —
Badger Meter Mfg. Co. ... —
Barrett Div., The ... —
Belco Industrial Equipment Div., Inc. ... —
Bethlehem Steel Co. ... 3
Buffalo Meter Co. ... 67
Builders-Providence, Inc. ... 11
Calgon, Inc. ... 15
Carson-Cadillac Co. ... —
Cast Iron Pipe Research Assn., The ... 34–35
Central Foundry Co., The ... —
Centriline Corp. ... 61
Chain Belt Co. ... —
Chicago Bridge & Iron Co. ... 33
Clow, James B., & Sons ... ix
De Laval Steam Turbine Co. ... 77
Dorr Co., The ... Cover 3
Dowell Incorporated ... —
Dresser Mfg. Div. ... —
Economy Pumps, Inc. ... 55
Eddy Valve Co. ... ix
Electric Fish Screen Co. ... —
Electro Rust-Proofing Corp. ... 8
Ellis & Ford Mfg. Co. ... —
Everson Mfg. Corp. ... 54
Fairbanks, Morse & Co. ... —
Flexible Sewer-Rod Equipment Co. ... —
Ford Meter Box Co., The ... 73
General Chemical Div., Allied Chemical & Dye Corp. ... —
Greenberg's, M., Sons ... —
Graver Water Conditioning Co. ... 23
Hamilton-Thomas Corp. ... 55
Harco Corp., Rusta Restor Div. ... —
Hayman, Michael, & Co., Inc. ... 16
Hays Mfg. Co. ... 57
Hellige, Inc. ... 22, 44
Hersey Mfg. Co. ... 49
Hungerford & Terry, Inc. ... 50
Hydraulic Development Corp. ... 5
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. ... x
Inertol Co., Inc. ... —
Infilco, Inc. ... vii
Iowa Valve Co. ... ix
Johns-Manville Corp. ... —
James Jones Co. ... 31
Keasbey & Mattison Co. ... 75
Kennedy Valve Mfg. Co., The ... 13
Klett Mfg. Co. ... 48
Koppers Co., Inc. ... 41
Kupferle, John C., Foundry Co. ... 16
LaMotte Chemical Products Co. ... —
Layne & Bowler, Inc. ... 47
Leadite Co., The ... Cover 4
Lock Joint Pipe Co. ... i
Ludlow Valve Mfg. Co. ... —
M & H Valve & Fittings Co. ... 43
Mueller Co. ... —
National Cast Iron Pipe ... ix
National Water Main Cleaning Co. ... 21
Neptune Meter Co. ... iii
Northern Gravel Co. ... 22
Northrop & Co., Inc. ... 14
Omega Machine Co. (Div., Builders Iron Fdry.) ... 65
Peerless Pump Div. ... —
Permutit Co. ... 45
Phelps Dodge Refining Corp. ... —
Philadelphia Gear Works, Inc. ... 4
Photovolt Corp. ... —
Pittsburgh-Des Moines Steel Co. ... 17
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) ... 78
Pollard, Jos. G., Co., Inc. ... 12
Portland Cement Assn. ... —
Proportioneers, Inc. ... 29
Reilly Tar & Chemical Co. ... —
Rensselaer Valve Co. ... 59
Roberts Filter Mfg. Co. ... 39
Ross Valve Mfg. Co. ... —
Simplex Valve & Meter Co. ... —
Smith, A. P., Mfg. Co., The ... 19
Solvay Sales Div., Allied Chemical & Dye Corp. ... 52
Sparling, R. W. ... 53
Stuart Corp. ... 42
Tennessee Corp. ... 6
U. S. Pipe & Foundry Co. ... v
Virginia Smelting Co. ... —
Walker Process Equipment, Inc. ... 71
Wallace & Tiernan Co., Inc. ... xii
Warren Foundry & Pipe Corp. ... 9
Well Machinery & Supply Co. ... 37
Welsbach Corp., Ozone Processes Div. ... —
Wood, R. D., Co. ... Cover 2
Worthington-Gamon Meter Co ... 7

Directory of Professional Services—pp. 24-27

Albright & Friel, Inc.
Alvord, Burdick & Howson
Bays, Carl A. & Assoc.
Behrman, A. S.
Black Labs., Inc
Black & Veatch
Clinton L. Bogert Assoc.
Bowe, Albertson & Assoc.
Buck, Seifert and Jost
Burgess & Niple
Burns & McDonnell Eng. Co.
Caird, James M.
Camp, Dresser & McKee
Chester, Engineers, The
Consoer, Townsend & Assoc.
De Leuw, Cather & Co.
Fay, Spofford & Thorndike
Fent, O. S.
Gannett Fleming Corddry & Carpenter, Inc.
Gilbert Assoc., Inc.
Glace, Ivan M.
Greeley & Hansen
Havens & Emerson
Haydock, Charles
Hitchcock & Estabrook, Inc.
Horner & Shifrin
Hunt, Robert W., Co.
Jones, Henry & Schoonmaker
Knowles, Morris, Inc.
Leggette, R. M.
Roberto Meneses Hoyos & Co.
Metcalf & Eddy
Nutting, H. C., Co.
Parsons, Brinckerhoff, Hall & Macdonald
Malcolm Pirnie Engineers
Pitometer Co.
Purcell, Lee T.
Riddick, Thomas M.
Ripple & Howe
Rose, Nicholas A.
Russell & Axon
Sirrine, J. E., Co.
Stanley Eng. Co.
Stilson, Alden E. & Assoc.
Ward & Strand
Weston & Sampson
Whitman & Howard
Whitman, Requardt & Assoc.

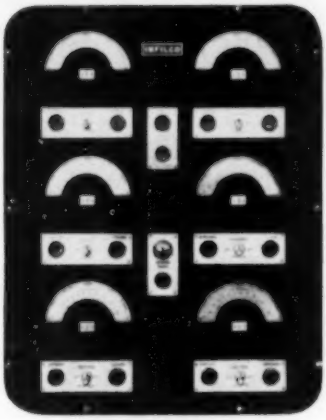
Continuous Sludge Removal at Low Cost!



Water Treatment Plant . . . Muskogee, Okla.

ACCELATOR®

With Infilco PUSH BUTTON FILTER CONTROL Gives Muskogee Greater Capacity in Far Less Space!



An ACCELATOR only *70 feet square* softens and clarifies TWICE as much river water for Muskogee, Okla., as the former method did in a space 210 feet square! Extreme flexibility of operation with a remote push button filter control system centralized on one panel, is a feature of this highly satisfactory installation. The flow through all filters is maintained at a uniform rate and increased or decreased as desired by simply pressing the proper button!

ACCELATORS invariably give simpler operation, faster chemical reaction, higher ratings and an exclusive slurry recirculating feature which produces better, clearer water in less time. They can effect up to *80% savings in space!* Mixing, coagulating, settling, and sludge removal . . *all* these operations are replaced in ONE COMPACT UNIT! ACCELATOR installations are now economically treating over *One Billion* Gallons of water daily. Get all the facts. Send for our new 28 page bulletin No. 1825. Write today!

INFILCO

• BETTER WATER CONDITIONING AND WASTE TREATMENT SINCE 1894 •

INFILCO INC.

GENERAL OFFICES: 325 WEST 25th PLACE • CHICAGO 16, ILLINOIS

SALES OFFICES IN TWENTY SIX PRINCIPAL CITIES

WORLD'S LEADING MANUFACTURERS OF WATER CONDITIONING AND WASTE TREATING EQUIPMENT

COMING MEETINGS

A.W.W.A. 1950 ANNUAL CONFERENCE

Philadelphia, Pa.

May 21–26

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1950 Conference except as they are requested on the standard form prepared by the A.W.W.A.

Accommodations at Eleven Hotels

All Technical Sessions and Exhibits at Convention Hall

February 15—New Jersey Section Luncheon at Essex House, Newark. Secretary: C. B. Tygert, Box 178, Newark 1, N.J.

March 16—New England Section business meeting. Secretary: R. H. Ellis, Engr., Factory Mutual Eng. Div., 184 High St., Boston 10, Mass.

30–31—New York Section at Hotel Sheraton, Rochester. Secretary: R. K. Blanchard, Vice Pres., Neptune Meter Co., 50 W. 50th St., New York, N.Y.

31–Apr. 2—Arizona Section at Safford. Secretary: Mrs. Helen Rotthaus, San. Eng. Div., State Dept. of Health, Phoenix, Ariz.

April 3–5—Canadian Section at General Brock Hotel, Niagara Falls. Secretary: A. E. Berry, Dir., Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

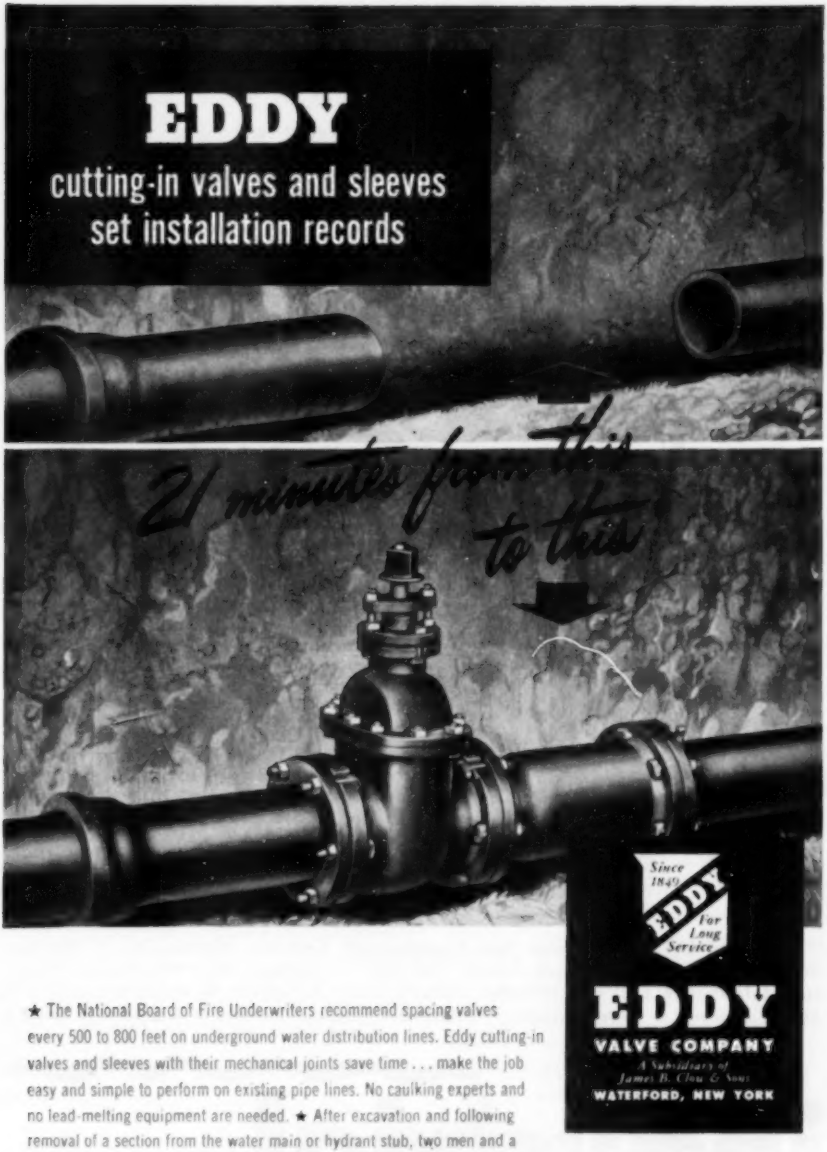
12–14—Illinois Section at LaSalle Hotel, Chicago. Secretary: Carl N. Brown, Western Sales Mgr., U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

20–21—Kansas Section. Secretary: H. W. Badley, Repr., Neptune Meter Co., 640 Highland St., Salina, Kan.

21–22—Montana Section at Florence Hotel, Missoula. Secretary: C. W. Brinck, Montana State Board of Health, Helena, Mont.

26–28—Indiana Section at Purdue Univ., Lafayette. Secretary: C. H. Bechert, Dir., Div. of Water Resources, Ind. Dept. of Conservation, 445 N. Pennsylvania, Rm. 200, Indianapolis 4, Ind.

May 11–13—Pacific Northwest Section at Hotel Winthrop, Tacoma, Wash. Secretary: Oscar P. Newman, Boise Water Corp., Boise, Idaho.



★ The National Board of Fire Underwriters recommend spacing valves every 500 to 800 feet on underground water distribution lines. Eddy cutting-in valves and sleeves with their mechanical joints save time . . . make the job easy and simple to perform on existing pipe lines. No caulking experts and no lead-melting equipment are needed. ★ After excavation and following removal of a section from the water main or hydrant stub, two men and a ratchet wrench can complete the job in twenty-one minutes—with all joints "bottle tight" under pressure. Work can be done in any kind of weather . . . in a flooded trench . . . fast and sure should emergency require. ★ Stock up now with Eddy cutting-in valves and sleeves and be ready for speedy, on the spot installations as circumstances may permit. Valves meet AWWA specifications . . . are available in sizes 3 to 12 inches . . . for use on both sand cast and centrifugally cast iron water pipe.

NUCHAR

NO PLACE FOR GRASS

THERE'S no place for grassy, fishy or other foul tastes and odors in the modern water distribution system.

And the modern way to detect and protect against these offensive tastes and odors is to use the Threshold Odor Test plus Aqua Nuchar Activated Carbon. The Threshold Odor Test supplies the means of measuring odor intensities in water, while Aqua Nuchar Activated Carbon has proved to be the most effective, economical method to remove objectionable tastes and odors from water supplies.

Threshold Odor Test demonstrations have been presented by our Technical Service Department at many schools throughout the country, and also to groups of health department and water personnel. Anyone interested in having such a demonstration presented, should write to our nearest office. Groups of up to 40 individuals can be accommodated at one time.

OTHER PRODUCTS: Snow Top Precipitated Calcium Carbonate • Nuchar Activated Carbons • Liqro Crude Tall Oil • Tallene Tall Oil Pitch • Indusoil Distilled Tall Oil • Tallex Abietic Acid • Sulfate Wood Turpentine • Alpha Pinene • Beta Pinene • Polycel Cellulose Fibers • Indulin (Lignin)

industrial CHEMICAL SALES

division west virginia pulp and paper company

NEW YORK CENTRAL BLDG.	PURE OIL BLDG.	PUBLIC LEDGER BLDG.	LEADER BLDG.
230 PARK AVENUE	35 E. WACKER DRIVE	INDEPENDENCE SQUARE	526 SUPERIOR AVE., N.W.
NEW YORK 17, N. Y.	CHICAGO 1, ILLINOIS	PHILADELPHIA 6, PA.	CLEVELAND 14, OHIO

Journal

AMERICAN WATER WORKS ASSOCIATION

COPYRIGHT, 1950, BY THE AMERICAN WATER WORKS ASSOCIATION, INC.

Vol. 42 • No. 2
February 1950

Contents

Obtaining Technical Services for Small Communities.....THOMAS M. NILES 107
The Consulting Engineer and the Water Works Operator
DONALD D. HEFFELFINGER 113
Organization and Financing of Maryland Sanitary Districts—*Panel Discussion:*
Organization Procedure.....I. ALVIN PASAREW 118
Methods of Financing.....N. L. SMITH & A. B. KALTENBACH 123
Public Authorities in Pennsylvania.....J. RAYMUND HOFFERT 127
Research on the Disposal of Radioactive Wastes..O. R. PLACAK & R. J. MORTON 135
Illegal Demands on Water Department Funds.....J. E. GOTHERMAN 143
Pennsylvania's Clean-Streams Program.....HOWARD E. MOSES 146
Developments in the Chlorine Dioxide Process.....R. N. ASTON 151
The Optimum Incubation Temperature for the Primary Isolation of Coliform Organisms.....JOANNA R. BONIECE & W. L. MALLMANN 155
Methemoglobinemia and Minnesota Well Supplies
H. M. BOSCH, A. B. ROSENFIELD, ROBERTA HUSTON, H. R. SHIPMAN & F. L. WOODWARD 161
Water Well Redevelopment by Explosives.....R. M. EBAUGH 171
Infiltration Gallery at Ontonagon.....GEORGE W. FRANCIS 186
Aboveground Pipeline Sections of Mokelumne Aqueduct..JAMES W. TRAHERN 189
Pipeline Location and Right-of-Way Problems.....CARL A. LAUENSTEIN 199
Recarbonation With Liquid Carbon Dioxide.....ARTHUR F. MELLEN 204
History of Water Supply in Russia—N. I. Falkovski, *book review*
V. V. DANILEVSKI 207

Departments

Officers & Directors	ii	Correspondence	20
Division & Section Officers	iv	Membership Changes	28
List of Advertisers	vi	Condensation	42
Coming Meetings	viii	Section Meeting Reports	56
Percolation & Runoff	1	Index of Advertisers' Products	72

Reproduction of the contents, either as a whole or in part, is forbidden, unless specific permission has been obtained from the Editor of this JOURNAL. The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*.
Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

Harry E. Jordan, Secretary—500 Fifth Avenue, New York 18, N.Y.

ERIC F. JOHNSON, *Editor* — LAWRENCE FARBER, *Associate Editor*
DANIEL N. FISCHEL, *Managing Editor* — ELIZABETH M. BRADY, *Associate Editor*

$7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—50 cents; single copies to non-members—75 cents.

8 YEARS AND STILL GOING STRONG

The ability of the Break-Point Process to meet the various demands of day by day operation is aptly shown by the case history of a municipal water works in Pennsylvania.

Since 1941, when it was installed at this plant by W&T Engineers, the Break-Point Process has played a major role in producing a pure, sparkling water for the system's many consumers. It has completely eliminated complaints on tastes and odors and has raised the finished water quality to such a high level that tests show *no* gas formers and *no* bacteria on the plates. In addition, a staff report continues, the Break-Point Process was of particular value in keeping the water acceptable to consumers during an emergency plant overload of 120%.

These accomplishments and such additional benefits as longer filter runs and iron and manganese removal are typical of what you receive with the Break-Point Process backed by W&T Equipment.

In the complete line of W&T chlorinating equipment, proved by over 35 years' experience all over the world, there is a chlorinator that will give *your* plant these benefits, too.

For more details write to your nearest W&T Representative — he'll be glad to help you.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES
S-44

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 42 • FEBRUARY 1950 • NO. 2

Obtaining Technical Services for Small Communities

By Thomas M. Niles

A paper presented on Nov. 4, 1949, at the Chesapeake Section Meeting, Washington, D.C., by Thomas M. Niles, Partner, Greeley & Hansen, Chicago.

IT is generally recognized that small communities as well as large cities need and should have competent technical advice, but questions arise concerning the availability of the services of the most experienced and competent engineers, the procedures to be followed in obtaining such services and the price to be paid for them. Although there are no specific and final answers to these questions, certain basic considerations should be kept in mind.

Generally speaking, the per capita cost of municipal installations is higher for small communities than for the larger cities, since small structures cost more per unit of volume or capacity than large ones. In water systems, the requirements for fire protection are higher for the smaller communities in comparison with normal uses. For reasons of economy, therefore, the need for adequate, competent technical services is at least as great in small as in large communities, and perhaps greater.

The problem of obtaining technical services is essentially the same regardless of the size of the community. No standard procedure exists and none can be stated. The objective, however, is clear: to follow a procedure which results in the greatest overall efficiency and economy.

Technical Services Needed

Nearly all elements of the water system will require technical services at one time or another. The wells, dams, reservoirs, intakes, pumping stations and pipelines should receive competent engineering study. Treatment plants for the improvement of water quality are often required. Distribution of the water to the points of use involves pumping stations, transmission mains, storage reservoirs, elevated tanks and

the distribution pipes, valves and hydrants. The entire system is interrelated and must be properly planned in its entirety. It must be secure under emergency conditions and, in both construction and operation, should represent an economical installation.

The need for expert advice on extensions, additions and modifications to existing works may be less critical, particularly if the improvements are minor. Problems of repairs, replacements and maintenance operations may or may not require specialized technical services.

Some systems have inherent inadequacies, whereas others develop deficiencies as the community grows. In almost every system, betterments will at one time or another be needed to provide additional capacity or improved pressures, quality, security or economy of operation. Thus, the need for competent technical advice is likely to arise at intervals in any community, regardless of size.

Competent engineering is the best insurance against wasteful expenditures on improvements which, when completed, will not perform the desired function, and against greater expenditures than are needed to produce the desired results. It insures that the most favorable and economical way to meet the problem will be found and that the project will be carried out at the lowest total annual cost. Sufficient care and attention to detail in the preparation of plans and specifications result in the lowest possible bids and the avoidance of costly extras during construction, which alone may amount to several per cent of the construction cost.

The technical services that may be needed by a community fall into a variety of classes, including:

1. Preliminary investigations and reports
2. Designs, including plans, specifications and contract documents
3. Supervision of construction
4. Supervision of operation
5. Advice on financing
6. Rate studies
7. Appraisals
8. Expert testimony
9. Checking of designs
10. Consultation on designs
11. Review of comprehensive programs
12. Special services.

Whatever the problem, competent engineering, properly related to the needs of the system, will more than pay for itself.

Cost of Technical Services

The price which the community should pay for technical services depends on a number of factors and, in the final analysis, cannot properly exceed the actual value of the services. Competent and thorough engineering results not only in the lowest possible construction costs, but also in the safety, security, economical operation and long useful life of the improvement. Engineering effort must, of course, be paid for, and, for a very small project, the cost of extremely thorough and detailed engineering effort would exceed its worth to the project and to the community. As an extreme example, suppose that a new concrete walkway 2 ft. wide and 50 ft. long is planned, at a cost of perhaps $50. Complete engineering services—including a preliminary investigation and report, field surveys, detailed design, plans and specifications, contract documents and supervision of construction—would cost at least sev-

eral hundred dollars and would obviously not be worth while.

The relationship between the size of the project and the extent of engineering effort is generally recognized by engineers and clients and is taken care of by a reasonable adjustment of the extent of the engineering effort, and the fees paid therefor, to the magnitude and importance of the project. Thus, although the percentage of project cost charged by engineers is higher for small projects than for large ones, the extent of detail covered is generally less for small projects than for larger ones.

There is not much difference in the cost of engineering services provided by the most experienced and best qualified engineers and by those with relatively little experience. The experienced and competent engineer is more proficient and can do a better job with less effort than the inexperienced one. Consequently, a balance tends to be struck between efficient operation and familiarity with the problem on the one hand and possibly lower overhead costs and shorter travel distance on the other.

Generally speaking, the larger communities can afford to go farther afield in engaging technical services than can the smaller ones, as, for the latter, travel time and expense may be relatively high in comparison with the total engineering cost. The effect of distance on the selection of engineers is related to the intricacy and importance of the problem. The smaller community, for instance, can afford to pay some premium for the best technical services when the problem is difficult. It is probably true that, for any community with a population larger than 10,000–15,000, distance is not usually a determining factor. For communities below 5,000, however, the cost of travel from remote home offices may reach appreciable proportions when compared with the total cost of the technical services. Such communities may find it wise to consider only the nearby engineering firms or those active on other projects in the vicinity. Often the services of nearby firms may be supplemented by the advisory guidance of a more experienced engineer.

Sources of Technical Aid

Depending on the nature of the problem, the necessary technical services may be supplied by one or more of several agencies.

1. *Practicing engineers specializing in the particular field in question* should ordinarily be employed when the problem is difficult and the project is of considerable importance. This is particularly true for new projects or major improvement programs.

2. *The city engineer and his staff* can usually render adequate service if the improvement consists of normal and routine maintenance or repairs, or involves extensions and additions similar to existing installations. On a major project, even though he may be qualified to perform the desired services, the city engineer is usually too busy to undertake the work in addition to his regular duties.

3. *State boards and departments* may be called upon for advice on needs, safety and health standards, and procedure.

4. *Local fire insurance inspection bureaus*, and similar organizations, may point out the need for improvements and make certain recommendations for the correction of deficiencies.

5. *Trade or industrial associations*, such as the Portland Cement Assn. and the Cast Iron Pipe Research Assn.,

can frequently answer questions on the use of the products with which they are concerned.

6. *Manufacturers of equipment* are in a position to give valuable advice on questions of maintenance, repairs and replacements for their own equipment. They should not be requested to provide overall engineering advice or technical services.

7. *Local contractors* are frequently able to make useful suggestions on minor building repairs and the like and to offer expert testimony on construction matters.

8. *College professors* are available for technical advice on special problems with which they are familiar, as, for instance, consultation or cooperative advice on basic technical matters when their knowledge rests on scientific research in the particular field involved.

Qualifications of Engineers

The more important qualifications which should be looked for in the selection of engineers are integrity, education and technical knowledge, professional outlook, experience, judgment based on experience, facilities for doing the work, and organization.

Integrity, technical knowledge and professional outlook are of primary importance. Without experience and the exercise of judgment based on it, the results are likely to be experimental and impracticable. Needless to say, a well equipped office and a competent staff of engineering assistants and draftsmen are essential for successful and expeditious performance of the services desired.

Occasionally it is suggested that, as the young engineer has to start somewhere, he should be employed on the smaller projects. The soundness of this procedure is open to question. The small communities should not offer themselves as guinea pigs. The young engineer should expect to gain his experience by many years of work under or in association with older, experienced men. Having become proficient in his specialized field, he may then honestly and conscientiously open his own office or advance to a position of full responsibility.

Size in an engineering organization is not necessarily indicative of competence. Engineering should be a personal service, and great size may not be, and probably is not, compatible with competence. Breadth of experience, however, is important. A record of continuing engagements on many large and small projects is usually an indication of competence and integrity.

It is not true that the large engineering firms are interested only in extensive projects. Actually, 50–60 per cent of the engagements of the large firm may be for communities of less than 10,000 population. In the author's firm, nearly 60 per cent are in this category, and about 20 per cent have been for such clients as schools, camps and private residences.

Finding Qualified Engineers

Reputable engineers do not advertise their availability or services beyond the insertion of professional cards in directories of engineers contained in technical magazines. Reference may be made to such sources when the community does not have direct knowledge of the engineering firms that may be available. The size of the card does not necessarily bear a relationship to the competence of the firm listed.

Selections made by the larger communities may be a useful guide to the smaller towns in considering the engineers to be engaged. Responsible of-

ficials of the larger communities may be asked who has performed technical services for them and whether or not the results have been satisfactory.

For major projects, one or two newspaper stories mentioning the improvement and the intention to secure properly qualified technical assistance may result in considerable interest on the part of engineering firms, which will then write to the city asking about the project and requesting consideration when engineers are to be engaged.

Some of the technical magazines publish lists of proposed projects. Brief news items may be sent to such periodicals, and the project can thus be brought to the attention of interested engineers.

Attendance at technical society meetings offers valuable opportunities to talk with officials of other communities and to ask about their experiences with different engineering firms.

The national societies themselves can help by advising small communities and others of the proper procedure for selecting and engaging technical services.

Direct letters to a few of the engineering firms generally known to be well qualified will be fruitful. They will often be interested themselves, and, if not, they will frequently suggest the names of competent firms, located closer to the community, which are experienced in the field in question and which they feel free to recommend.

The more complex and important the work and the greater the amount at stake, the more important it is for the community to obtain the best engineering talent available. If an engineer has rendered satisfactory service in the past and is familiar with the local system and conditions, the community may best be served by the engagement of the same engineer for the new work; otherwise, a new selection must be made. When the initial inquiries have resulted in a decision on the engineer to be engaged, it is neither necessary nor desirable to consider or request interviews with or proposals from other engineers. It is sufficient to enter into an agreement with the engineer selected, describing the services to be performed and the proper compensation to be paid. The fees, if in general accord with the recommended fee schedules of national or state technical societies, will be about the minimum for which adequate technical services can be performed.

If in doubt about the engineer best qualified, the community should write to several engineers and by correspondence and conferences determine which one is best able to perform the services satisfactorily. When the selection is difficult, it may be desirable to request the engineers under consideration to submit written proposals stating the services to be performed and the compensation to be paid. Such proposals should be accompanied by a description of the qualifications and experience of the engineers sufficient to indicate competence in the performance of the services desired. Competition, if any, should be on the basis of qualifications, not price. Bargain prices should always be avoided as they are almost certain to result in inadequate engineering effort.

Agreements

The engineering agreement should state the services to be performed and the compensation to be paid. The quality of engineering cannot be specified. It may be understood that reputable engineers will give the project the benefit of their best efforts and

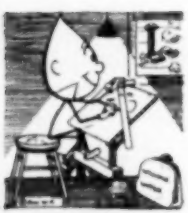
judgment and will serve the interests of the client to the best of their ability.

If the project is a comprehensive one, the agreement may well cover several successive steps of the expected continuing procedure. The total fee should ordinarily be broken down according to the various parts of the work—for example: [1] preliminary investigation and report; [2] design, plans and specifications; and [3] supervision of construction. A fourth item, supervision of operation, may also be included. The agreement should be flexible and the community should have the right to terminate the employment at any time, provided the engineer is properly paid for work completed. Unless an initial decision has been made to carry the project through to completion, it is frequently desirable that the agreement require successive authorizations for the start of each phase of the work. For instance, following the preliminary investigation and report, the city may or may not decide to proceed with the design and, after completion of the plans and specifications, may or may not decide to proceed with construction. Contingent agreements according to which there will be no payment for the preliminary investigation and report unless the city decides to go ahead with the design, or no payment for plans and specifications unless the project proceeds to construction, obviously will not result in competent work and should be avoided. Also to be avoided are agreements under which the community obligates itself to employ the same engineer for subsequent work if and when the project becomes active.

The fundamental consideration in the agreement should be that proper services will be rendered and proper compensation paid for them.

Conclusion

Municipal officials are charged with the responsibility of guarding the welfare of the community. Obtaining competent technical services is their best insurance that the interests of the citizen will be safeguarded, that costly mistakes will not be made and that the improvements constructed will be adequate, economical and of lasting value.



The Consulting Engineer and the Water Works Operator

By Donald D. Heffelfinger

A paper presented on Nov. 3, 1949, at the Ohio Section Meeting, Dayton, Ohio, by Donald D. Heffelfinger, Engr.-Supt., Water Works, Alliance, Ohio.

CONSULTING engineers and water works operators are two groups whose work is complementary, the former being concerned with the design and construction of the works and the latter with the operation of the completed plant. Both are striving toward the same goal—the economical and efficient production of a safe, palatable water supply—and this objective can be reached only through close cooperation between the two. As each is dependent on the other and neither can be completely successful without help from the other, it seems reasonable for the engineer and operator to assist one another in every possible way.

Design and operation are related functions. It has often been said that the poorest design becomes good in the hands of a capable operator, while the best design will not produce results with an incompetent operator. It takes the training and experience provided by both parties to achieve results.

Position of Engineer

The engineer not only has to satisfy the operator, but he must also meet the requirements of the state health department, the city council and other public officials and boards. He must produce a plan which will be economical in construction and operation, flexible, correct in hydraulic, sanitary and structural design, and adapted to specific local conditions, while using standard methods and materials of construction. He must keep the cost of the installation below an amount provided by local officials and often must complete the design within certain time limits. Therefore, he finds it necessary to compromise in order to fulfill these various conditions, and it is little wonder that he must omit and change some items in favor of others.

In order to plan any new plant or addition intelligently, the consulting engineer must have correct information. If the operator has kept accurate, detailed and orderly records of plant operation and performance, as well as complete laboratory and other pertinent data, the facts upon which to base a proper design are at hand, and the chances for an operator to obtain a plan designed specifically to meet the problems of his particular water supply are greatly enhanced. If these records are not available, the engineer can only be guided by his past experience, by information from similar plants and by data that can be collected locally over a limited period and only under certain conditions.

The engineer must employ certain fundamental principles of hydraulic, sanitary and structural design and

must specify materials and methods of construction which are familiar to the type of contractor likely to be attracted to the job. The equipment recommended must have been proved in plant operation. Meeting these requirements often forces the engineer to adopt designs which may seem unjustified to an operator not acquainted with the engineering problems involved. Frequently the requirements and existing conditions are in conflict with each other, as, for example, when a design which is particularly favorable to the operator entails difficult and unusual construction for the contractor and additional expense for the city. The final design, therefore, must be a series of compromises based on the judgment of the engineer.

The consulting engineer also faces problems not truly of an engineering nature, the most serious being financing. Too often rising prices, enlargement of the scope of the work or insufficient appropriations make it necessary for the engineer to alter his original plans materially. He must cut and trim wherever possible and many desirable features may have to be omitted. These are frequently items of convenience for the operator. The work of the operator may have to be considered as time at so many dollars and balanced against certain equipment and design costs, which will mean that the operator will have greater difficulty in obtaining the desired results. Yet this problem is usually beyond the control of the engineer, although it is his duty to attempt to see that sufficient funds are provided for construction and operation and to warn of the difficulties to be experienced if funds are lacking.

Operators often fail to consider the original cost very seriously, partly because they know how hard it is to get items later on which could have been included in the original plan. It should also be pointed out that engineers often eliminate minor features which are of little significance in the overall cost but which greatly add to the convenience of the operator's daily routine. Moreover, not all instances of poor design can be attributed to lack of funds.

Another problem which the consulting engineer faces and which subjects him to some undue criticism is the selection of equipment. If the engineer writes specifications for an item so that they can be met by only one manufacturer, whose product the engineer or the operator feels is best, competition is thereby eliminated and the engineer is open to criticism. On the other hand, if he draws up less restrictive specifications, he may unavoidably let in an inferior product.

The engineer is often blamed for the faulty operation of equipment. It is his duty to explain the function and care of the equipment as far as possible, but the operator must often look to the manufacturer for certain information.

Too often politics becomes a problem to the engineer. The design for an installation may have been prepared during the administration of one political party, while the operation of the plant is begun under another. In the interim platforms of economy and various political maneuvers may cause the engineer untold headaches and even require changes in the plans.

As an operator, the author feels that the consulting engineer should be sufficiently experienced and competent to be able to balance the various factors mentioned and produce a design meeting the above requirements. He should treat each plant as a distinct, individual

problem and design for specific conditions, not making the plant a mere carbon copy of a previous one. He should listen to the suggestions and problems of the local operator and cooperate with him, for the operator is the one who must make the plant work after the engineer and contractor have gone.

The consulting engineer should be experienced in construction methods and materials and should keep abreast of developments in this connection. He should be thoroughly versed in plant operation and should try to foresee operating difficulties and provide for them. He should appreciate the operator's viewpoint and problems and attempt to eliminate routine and nuisance jobs. If the engineer puts himself in the operator's place, his design will be much less likely to be criticized by the operator. Storage facilities, chemical feeding and handling devices, ladders, stairs, doorways and walkways, poorly drained dark pits, submerged equipment, valve and sluice gate installations, clear well and basin drains, pipe galleries and lack of automatic equipment are a few of the items which are often the subject of criticism by operators and merit particular attention.

The engineer should strive for simplicity, avoiding complicated designs and equipment which merely increase the points where trouble may occur, especially in smaller plants. The plant should also be flexible in operation. As a particular design for plant operation may produce difficulties, other methods of operation should not be ruled out. Two or more small units are usually better than a single large one for the purposes of repair, cleaning and the like, since some units will always be available for use. The plant should be convenient and easy to operate under all weather conditions; valves and mechanical equipment should be readily accessible for operation, repair and lubrication; and sufficient lighting should be provided. Cranes and hoists should be included in the original design, as well as all tools necessary for plant operation. Grading, seeding and landscaping should always be provided for by the engineer.

Careful design must be followed by good construction. The consulting engineer must make proper inspection during construction; otherwise, poor work will result no matter how well the plans are prepared and the specifications written. The contractor, the resident engineer and the inspectors should be carefully selected.

Position of Operator

The problems of the operator are of an entirely different character from those of the consulting engineer. It is the operator's job to take the completed plant and run it in an efficient and economical manner to produce a safe, palatable water. This may seem to be much the easier of the two jobs, but in practice it is not so simple. Only through experience, training, constant vigilance, hard work and attention to innumerable details can the desired results be obtained.

The operator, too, has to satisfy others—not only the engineer, the local public officials and the state department of health, but the general public as well. He must operate the plant wisely, maintain the buildings and grounds to present a pleasing appearance, and show a sympathetic, cooperative and patient attitude toward all concerned. The operator also has his share of political problems, but these are better left unmentioned.

The operator must run his plant economically. He must improvise and meet emergencies and accomplish results with little expenditure. He has a budget within which he must operate, so that he cannot complete items or buy equipment or tools which should have been included in the original plan. The operator expects his new equipment to be well made and long lasting, for to request a replacement in the first few years of operation is a reflection on him.

The operator must run laboratory analyses, keep records, make reports and still get his other work done. He must acquire sufficient information to point out any required changes in operation and must provide data for use by engineers in designing these changes. He expects sufficient laboratory facilities, equipment and record storage space to render this task feasible.

The operator must understand his equipment and make it work, yet he cannot spend all of his time adjusting equipment and making changes. He has a right to expect that most of the "bugs" have been taken out, that the equipment is relatively foolproof and free of trouble, and that he is not operating a piece of experimental apparatus. Otherwise, he will probably be faced with serious interruptions in operation. Sometimes the designer hopes to gain fame and prestige by being the first to adopt some new device or process which has not been proved under plant conditions. The trend toward mechanical equipment lessens the labor required but also demands a higher type of operator.

Another problem faced by the operator is to keep his plant going during periods of construction. The contractor is interested in doing the job as cheaply and quickly as possible, but often the quick way would mean seriously imperiling the operation of the plant and the quality and safety of the effluent. The operator must insist on adequate operating facilities during construction. The consulting engineer should support the operator and can help greatly by requiring the contractor to provide a proposed work schedule sufficiently far in advance to enable the operator to prepare for changes and omissions in operating procedures. The engineer should also specify in what manner the contractor may use the premises in order to interfere as little as possible with operation.

The operator should be given an opportunity to review the consulting engineer's preliminary report when possible, and he should be consulted by the engineer on details of operation as plans and specifications are prepared. The operator should also have a chance to study the completed plans and specifications.

It is important that all operating instructions for various items of equipment be turned over to the operators. Engineers and contractors receive complete installation and operating information on equipment from manufacturers, but too often these data are not passed on to the operator when installation is completed. As a result, equipment may be improperly lubricated, and months later, when it is necessary to order new parts, no lists are available.

The operator has one major advantage over the engineer—he usually has the last say. After the plant is in operation, he can point to the mistakes, omissions and unforeseen adverse conditions which develop and explain what the design should have been. It is very easy to find fault with the work of others and it is likely that most op-

erators indulge in some second-guessing.

The operator must, however, accept his share of responsibility for making the plant work. It is up to him to produce the best obtainable results with the plant provided. He must be sympathetic and appreciative toward the design, willing to try anything, to meet conditions as they arise and to make the most of every device in his plant. Instead of blaming the engineer for something the operator thinks is missing or poorly designed, it is his duty to operate the plant with the existing facilities.

A reputable, experienced consulting engineer has a broader background and more experience in the design and construction field than the operator and should have good reason for his choice of design. The engineer has a knowledge of some factors which the operator may not fully appreciate. It is difficult for an operator to differentiate between faulty design and the requirements of economy or construction. The operator should rely on the wisdom of the consulting engineer, whose education, training and experience have provided him with the ability to weigh properly the various factors which may influence the design. Many engineers have former operators on their staffs and are thoroughly familiar with plant operation.

Constructive criticism should be offered the engineer by the operator, who should not feel that he is complaining when making suggestions or pointing out mistakes, because it is the alert, wide-awake operator who is quick to notice where improvements can be made. Neither should the engineer feel that the operator is too critical, nor hesitate to accept advice or information, because the operator is closest to the job and only through him can the engineer learn of operating difficulties and so improve his design.

As mentioned previously, the operator should strive to keep accurate, detailed records of plant operation and performance, including costs. These records should be summarized and reports should be written containing the pertinent data, so that information can be made readily available to all.

With hard work and honest effort, the operator should attempt to make the most of the devices he is furnished. He should study the engineering plans and become completely familiar with every detail. The operator should attempt to improve himself in every possible way, by reading the various periodicals, manuals and books in the water supply field; by attending short schools and sectional and state meetings; and by visiting other plants and studying their reports. Like the engineer, the operator must keep up with the changes and developments in his field so that he can use the plant facilities to best advantage.

Conclusion

Successful water treatment is not a problem for consulting engineers alone, or for operators alone, but one which can be solved only when both parties cooperate fully and render each other every possible assistance. Improvements in both design and operation will result from such cooperation. Above all, each must remember that the other is only human. The perfect set of plans and specifications has not yet been created—neither has the perfect operator.

Organization and Financing of Maryland Sanitary Districts

By I. Alvin Pasarew, N. L. Smith and A. B. Kaltenbach

A panel discussion presented on Nov. 4, 1949, at the Chesapeake Section Meeting, Washington, D.C., by I. Alvin Pasarew, Director, State Planning Commission, Baltimore, Md.; and N. L. Smith, Chief Engr., and A. B. Kaltenbach, San. Engr., both of Baltimore County Dept. of Public Works, Towson, Md.

Organization Procedure—*I. Alvin Pasarew*

A SANITARY district has been defined as "a local governmental unit created under a state enabling act to finance, construct and operate works for the collection and treatment of sewage, including industrial wastes amenable to joint treatment, and to provide adequate final disposal of the effluent and of the by-products of the treatment processes" (1). The development of sanitary districts has paralleled the expansion of the country's major cities into large metropolitan areas.

In the course of formulating a functional plan for the Baltimore metropolitan area (2), the author had an excellent opportunity to review the growth of metropolitan districts in the United States and the activity of community life originating and expanding outward from the central city. It was apparent that the hundreds of thousands of suburbanites who live beyond the city limits of the nation's 140 metropolitan districts have as much practical interest in the public facilities of the city as those who live within its boundaries. Yet, because of their preference (or necessity) for suburban living, these persons are deprived of the more adequate services which a well organized municipality can provide.

The core of this problem was summarized with great clarity by Hall (3), when he pointed out some years ago that: "The very nature of development in the suburbs of large cities introduces problems in the installation of sewerage systems that are not encountered in the cities themselves. The suburbs grow along transportation lines and main highways leading from the cities, creating separate areas of population, with much intervening less accessible territory, which is sparsely settled, while development in the cities is relatively compact."

During the author's investigation, he observed with keen interest the growth and development of the existing sanitary districts in the United States and was impressed with the variety of their organizational plans for providing water and sewerage facilities to fast growing suburban areas. At present most of the central cities of metropolitan areas with populations of over 700,000 furnish water to the suburbs that are closest to the city line. New York and Chicago are required to do so by law.

Baltimore, however, is the only central city that has constructed and operated a comprehensive suburban distribution system. Since there are no incorporated municipalities in Baltimore County, such a system was not only needed there, but was effectuated more easily through the organization of the Baltimore County Metropolitan Dist. in 1924.

Maryland Sanitary Districts

The Baltimore County sanitary district is one of the three main districts operating in Maryland, the others being the Washington Suburban Sanitary Dist., created in 1918, and the Anne Arundel County Sanitary Commission, established in 1922. It has been pointed out on good authority that the existence of these three districts "has made possible and has greatly stimulated the remarkable growth in population and assessable basis in the suburban sections of the counties near Baltimore and Washington" (4).

Besides these large units, existing legislation provides for five other sanitary districts in Maryland: the Allegany County Metropolitan Commission, the Annapolis Metropolitan Sewerage Commission, the Cresaptown Improvement Assn., the LaVale Sanitary Commission and the Howard County Metropolitan Commission (*see* Table 1). The Allegany County unit was set up at the 1949 session of the Maryland General Assembly. In keeping with its enabling act, the new metropolitan commission is authorized to perform the following functions:

> To create certain sanitary districts within Allegany County, Md., and to incorporate the same; to provide for the government thereof; to provide for the construction, maintenance, operation, purchase, condemnation or acquisition by gift of water supply, sewerage and drainage systems; and the purchase or condemnation of any land, structures or buildings or any stream bed, waterway, water rights or watershed or any rights therein required for use in the construction, maintenance or operation of water supply, sewerage and drainage systems; to provide for the issuance of bonds for the purpose of such construction and the levy of taxes, assessments and benefits, water charges and rates for payment of said bonds in each district; to provide for the operation, maintenance, regulation and control of said systems; and to provide penalties for certain offenses defined in the act. . . .

In the author's opinion, the law establishing the Allegany County Metropolitan Commission can well serve as a model act. It might be added that the legislative authority for all the sanitary districts in Maryland is based largely on Chapter 122 of the Acts of 1918, which established the Washington Suburban Sanitary Dist.

Fundamental Considerations

The governmental units covered in the different authorizations comprise separate municipalities, special areas, parts of counties, entire counties and more than one county. The size of the suburban areas is not a major consideration in the organization of a sanitary district. As early as 1921 Morse and Wolman (5) observed that "the construction of adequate water and sewerage works in small villages is just as feasible . . . as in the large towns or in cities." They stressed the point, however, that in any sanitary district "the essential for maximum effectiveness is a central organization for ownership and control, with power to

issue its own certificates of indebtedness, to proceed with all new work as its judgment may dictate, to purchase, condemn or otherwise to incorporate previously installed systems, and to readjust prior financing, both with respect to the bondholders and the citizens."

Although the size of an area requiring sanitary facilities is not important in itself, there are certain fundamental considerations in the organization of any sanitary district for a given locality. In view of the cost and extent of present-day treatment facilities, it is necessary to examine the patterns of population and the amount of building activity and assessable property base in order to decide if a sanitary district is feasible financially. The district organization may not be the best answer to all sanitary needs outside of municipalities, particularly since this system cannot be used for those areas unable to foot the bill for decent garbage, water and sewerage facilities.

Fiscal methods have certainly progressed sufficiently in recent years, however, to provide new devices for making these facilities possible. Although the subject of finance is outside the scope of this paper, it is worth pointing out that there is no reason why the state should not be called upon to assist those areas which are unable to finance their own facilities. What the state has done through loans and grants to aid the counties in building schools, it could certainly also do to some extent in providing essential water and sewerage systems and treatment plants. It is a sound principle to let each community take care of its own needs, but Maryland long ago discovered that the greatest stimulation to self-help is a little extra assistance at the beginning, whether given on the municipal, county, state or federal level.

TABLE 1

Sanitary Authorities in Maryland

Unit	Enabling Act	
	Chapter	Acts of
Allegany County Metropolitan Commission	715	1949
Annapolis Metropolitan Sewerage Commission (Anne Arundel County)	104	1931
Anne Arundel County Sanitary Commission	245	1922
Baltimore County Metropolitan District	539	1924
Cresaptown Improvement Assn. (Allegany County)	169	1949
LaVale Sanitary Commission (Allegany County)	13	1947*
Howard County Metropolitan Commission	991	1943†
Washington Suburban Sanitary Commission (Montgomery and Prince George's Counties)	122	1918

* Special session.
† Superseded special taxing area in the First Election Dist. of Howard County, created by Chap. 394 of the Acts of 1931, for the purpose of providing the residents of the district with a water supply. Chapter 777, Acts of 1947, authorized the Howard County Metropolitan Commission to assume the obligations issued under the 1931 authorization.

Organization Procedure

The procedure for organizing a sanitary district may be stated very simply,

but its execution is a difficult feat at best. The 1933 report of the Water Resources Commission of Maryland (4), headed by Abel Wolman, provides an excellent explanation for the difficulties which beset the organization of sanitary districts: "Citizens do not react favorably to anything which savors of additional tax burden or benefit assessment, although the cost of installation and operation of the service generally is lower than it would be under any other arrangement." The answer lies, therefore, in the extension of public health education and in the enlistment of the public's active interest, support and willingness to do everything possible to bring about better sanitation in the community.

A public discussion of improved sanitary facilities requires a very basic approach, since the average citizen is not interested in community facilities if he can get along on his own. But the first time his well runs dry or he finds the water contaminated he is bound to ask, "Why don't we do something about it?"

Once the citizens of a community are aroused, they will not stop at asking questions. They will contact the county commissioners, the county engineer and the county health officer and demand action. The state senators and delegates, who are sensitive to local needs and crises, will also be brought into the picture. With the cooperation of the local civic groups, the community leaders will meet and form a committee to study the problem and recommend a course of action. The local engineer will be called in to advise the committee. If he recommends a new organization to install and operate new sanitary facilities, he will be expected to demonstrate the feasibility of his plan. He will have to assure the group that the property base is adequate for financing the improvements, that the rates will be reasonable and that the advantages to be gained will justify the size of the initial investment. Local banking interests will also be asked to judge the soundness of the plan, on the basis of their broader experience and outlook. It is important that the county officials and representatives in the state legislature be apprised of every step on the way, because their support of the plan is absolutely essential. It is equally important that the need for sanitary facilities be widely discussed in the community, so that every citizen will be aware of the problem and the solution proposed. The support of no quarter, from the corner drugstore to the county courthouse, should be overlooked.

The state department of health is ready and willing to answer all basic questions that may be raised by interested local groups about the feasibility of undertaking a sanitary project, the costs involved and the steps which must be taken to set the system in motion. It is important for the county commissioners to be brought into the picture early, so that they will have a full understanding of the problem and can advise the local groups on the financing of needed improvements. Once the local citizenry and authorities are convinced of the necessity for the new facilities, the battle is almost won. But the vigilance of the sponsoring group cannot be relaxed until the enabling act is passed by the legislature.

The state department of health and the department of legislative reference are well equipped to assist all citizens interested in drawing up legislation

providing for new sanitary commissions. With the county commissioners, state senators and delegates backing the bill, it should have clear sailing through the General Assembly, but the possibility of the bill's being emasculated in committee should not be overlooked. An active opposition may tear it apart by proposing amendments in the structure of the district and its assessable base, to such an extent that an ineffective organization will result. It sometimes appears that a weak unit, with little or no power to act, is more of an obstacle to improvements than no sanitary district at all. With a weak district in existence, the citizens are deluded into expecting improvements that may never materialize.

With the governor's signature, the bill becomes law on June 1 following the legislative session, unless it is passed as an emergency measure. It is then up to the local leaders and county commissioners to see that an effective organization is set up and maintained. Its administration and, particularly, its financing are all-important.

Rural Areas

It is necessary to note at this point that the problem of providing adequate sanitary facilities for scattered rural communities still remains to be solved. While attention has been directed toward solving the sanitary problems of the fast growing suburban areas, there has been a tendency to neglect the rural areas. The economic aspects of the rural problem are more difficult to resolve and offer a direct challenge to all sanitary engineers and public health officers who dare to enter this field.

In discussing the organization of sanitary districts, the author has intentionally avoided any methodical analyses of the different types of sanitary districts possible or of the variety of powers included in legislation for administering, financing or operating existing districts in the United States. It is recommended that the comprehensive A.S.C.E. report (1) on these subjects be reviewed in detail. Instead, the present paper has consisted of the personal impressions of one who has studied the problem from the overall viewpoint of regional or metropolitan planning.

A great deal has certainly been achieved since 1889, when the Chicago Sanitary Dist. was organized to protect the city's water supply by keeping Lake Michigan free from pollution. The fruits of 60 years of effort are just beginning to be visible, however, and there is a long, long stretch ahead before reaching the standards which have been set. Until a satisfactory device for providing sanitary facilities to the millions of persons residing in suburban areas and rural communities is found, the work must continue. If a way can be found to get the local areas to join with the state in furnishing these needed facilities, it might indeed be a step toward the final solution.

References

1. Organization, Financing and Administration of Sanitary Districts. Progress Rept. of San. Eng. Div. Committee. Proc. A.S.C.E., **71**:177 (1945).
2. Pasarew, I. Alvin. *A Functional Plan for the Baltimore Metropolitan District.* Maryland State Planning Commission, Baltimore, Md. (1948).
3. Hall, Harry R. Stream Pollution Problems in the Washington Suburban Sanitary District. Proc. 13th Ann. Conf., Md.-Del. Wtr. & Sew. Assn., p. 13 (1949).
4. Report of the Water Resources Commission of Maryland (1933).
5. Morse, Robert B. & Wolman, Abel. A Plan for Meeting Water Supply and Sewerage Costs. Eng. News-Rec., **86**: 944 (1921).

Methods of Financing—*N. L. Smith and A. B. Kaltenbach*

The state enabling act creating sanitary districts in Maryland provides the power to finance the projects through levies on the persons or properties within the boundaries of the district. There are two principal methods of levying taxes to retire the bond issues necessary to raise the required funds for the construction, operation, maintenance and administration of the projects. General-obligation bonds are retired from the general tax fund, while revenue bonds are retired by annual rentals based on the size of the property or the use of project facilities, or on combinations and variations of these elements.

Although financing through general taxation is no doubt the simplest method, there are many objections to it, probably the most important being the fact that all persons within a sanitary district contribute money for the support of the utilities regardless of whether they receive a direct benefit from them or not. Nevertheless, the installation of a water or sewerage system or the furnishing of refuse collection and disposal facilities does definitely contribute to the general sanitation and betterment of a community and is therefore of indirect benefit to those residing in a district who do not receive the services. It is on this basis that general taxation is justified as a method of financing in whole or in part.

Assessments overcome the nonbenefit objection since they are levied on the properties bordering on and capable of being served by the utility. Furthermore, since assessments are based on the size of the property, they reflect the proportional increase in value of the property when the service is made available. For that reason, the assessment rate for any specific project in a sanitary district cannot be changed once it has been established.

A third source of income is the charge paid by the user for service received. Water can be metered and an equitable payment determined based on the amount consumed. The quantity of sewage, however, can only be estimated, the base being either the water meter readings (since sewage is mostly used water) or the number and type of plumbing fixtures.

Rarely is one of the three basic income-raising methods used exclusively, except, possibly, the general tax levy. In the interests of equity, it is usually the practice to adopt combinations of the basic methods. Some districts pay construction costs by property taxes and operating costs by service charges. Frequently construction costs are paid by assessments. As all methods are employed in the Baltimore County Metropolitan Dist., a detailed description of its arrangements should prove an excellent example of the use of the various means.

Baltimore County District

The Baltimore County Metropolitan Dist., lying wholly within the county, has an area of 234 square miles with an estimated population of 250,000. It is under the jurisdiction of the county commissioners and was made a subdepartment of the Baltimore County Dept. of Public Works when the latter was established in 1948. The city of Baltimore, which is a separate political subdivision from Baltimore County, furnishes water to the metropolitan district and provides maintenance for the district's water distribution system.

The district enabling act is quite specific in ordering the methods to be used

for financing. It empowers and directs the county commissioners to fix an annual front-foot assessment on all properties abutting on a water main, sewer or drain, for the purpose of paying the interest and providing the sinking fund for the bonds issued. The act also empowers and directs the commissioners to make charges for connections to the water supply, sewerage or drainage systems; to make an annual sewerage service charge on every building and place having a connection to the sewer; and, in cooperation with the city of Baltimore, to establish water rates which are paid to the city for furnishing water and for maintenance. In addition, the commissioners may levy an annual tax against all taxable property in the district.

Property Classifications

For the purpose of benefit assessments, properties are divided into five classifications: agricultural, small-acreage, industrial or business, subdivision and remote property. A property may be reclassified at any time if its use changes. Agricultural property is exempted from front-foot assessments until it is connected to the utility, at which time the length of the assessed frontage is limited to a maximum of 150 ft. At present the annual front-foot assessment for agricultural property is $0.22 for water lines and $0.25 for sewers. The same rates apply to subdivision property and to the first 150 ft. of small-acreage property. The next 150 ft. of small-acreage property receives an assessment of $0.15 per year for water and $0.17 for sewers, while the balance of the frontage in this classification is assessed at $0.07 for water and $0.08 for sewers. These new rates are applicable to construction since January 1, 1948. Prior to that time rates were lower, and the lower rates, of course, prevail for properties bordering utilities constructed before that date. Business or industrial property bears an annual assessment of $0.29 per front foot for water and $0.33 for sewers.

The fifth class, remote property, has rates of $0.30 per front foot for water or sewers. It was established in recent years to provide service to developments that require long sewer interceptors or feeder mains because of their relative isolation. The law provides for the subclassification of the five categories, but this step has never been considered necessary.

Property owners are given the privilege of extinguishing the annual assessments within one year from the time the levy is made, by payment of the proportional cost of the project of which the property is a part. This extinguishment cost has been set at $3.20 per front foot.

Extension Agreements

The act states that each proposed project shall be self-supporting within a reasonable time after its completion. If estimates of the expected revenue show that the assessments and charges will not support the cost of construction, the project cannot be undertaken unless the residents requesting the extension of new lines will finance the deficit. This arrangement is of particular value to developers, and its benefits are made available to them in two ways. Under the so-called service extension agreement, the developer deposits with the metropolitan district the full cost of the utility extensions before houses are built in the subdivision. After the construction of the utilities and houses, the developer is refunded—to the extent that the

project is self-supporting—the proportionate cost of the utility for each property as it is connected and a normal assessment levied.

The second arrangement is frequently used when construction of houses is well under way before utilities are installed. By this method, the developer makes up any deficit resulting from the lack of sufficient revenue to pay utility construction costs.

In recent months the department of public works has set up a procedure to enable developers to procure all public improvements under a single agreement, inasmuch as the department includes the metropolitan district, the highways department, the buildings and zoning engineer's office and the division of sanitation. After bids have been received on water, sewerage and storm drainage, the developer deposits with the department of public works the deficit, if any, on water and sewage main extensions, plus the total cost of storm drains, street paving, curbs and gutters. When the project is completed, the developer petitions for the return of one-third the cost of storm drainage and one-third the cost of paving, curbing and gutters.

Payment for the cost of a house connection is made in full by the property owner at the time of connection. For sewers, the average charge is $4.00 per foot for one-half the width of the street right-of-way, which is considered equitable since the location of the pipe on one side of the street instead of in the center is due solely to engineering considerations. The charge for water connections and meters is $50 for ¾-in. services, $60 for 1-in. services and the equivalent cost of time and materials for larger services. Twin services are $40 each. These payments are made to the city of Baltimore, which installs the connection.

Service charges for sewage are based on the number of fixture units in a building. A fixture unit is defined as a water outlet capable of discharging up to 7½ gpm., and a schedule of annual charges is in effect which varies from a minimum of $6.32 for fifteen or fewer fixture units to $28.32 for more than 50 units. Industries discharging large amounts of waste pay on the basis of the quantity reaching the sewers.

The levy on all taxable property in the district, known as the ad valorem tax, is $0.03 per $100 of assessed valuation. On this tax depends the bulk of the financing of the nonassessable sewage interceptors and treatment plants, water and sewage pumping stations, and water reservoirs.

Although the enabling act intended storm drains to be financed in the same way as other district improvements, in practice a different method has been used. The design and construction of such drains had been under the Baltimore County Highways Dept. prior to the establishment of the metropolitan district, and they continued under this jurisdiction until the first part of 1948. In order to bring about a greater coordination in design and construction, the storm drainage department was at that time transferred to the district. Since the money for these drains had previously come from the public facilities bond issue, which is serviced and retired from the general tax fund of the entire county, the same method of financing was continued when the transfer of jurisdiction was made. All assessments, sewer service charges and ad valorem taxes are added to and shown on the county tax bill and must be paid at the same time as the county taxes. They constitute a lien on the property

which is superior to all other liens against it, subject only to the priority of certain other taxes. Storm drain charges bear the same interest and carry the same penalties in the event of nonpayment as do other county taxes.

Use of Funds

The enabling act requires the treasurer of Baltimore County to collect all of the assessments and charges, and the money so received must first pay the interest on the bonds. The commissioners then deposit the amount raised for the payment of the principal in a bank as a sinking-fund account. The act even instructs the commissioners how to invest the sinking-fund account. The money must be used to purchase metropolitan district bonds at not exceeding one point above the issue price and they must be held as an investment, with the interest paid to the sinking fund; or else U.S. government bonds or those of the state of Maryland must be purchased. Such bonds may be sold at any time to retire a district bond issue, or to buy metropolitan district bonds if such a change is considered advantageous. The amount of bonds which the district may issue is limited to a maximum of 7 per cent of the total county tax assessment value of property within the district.

It can be seen that the metropolitan district enabling act prescribes the method of financing in a very detailed manner and leaves only the setting of rates to the discretion of the commissioners. The fair distribution of costs among assessments, service charges and general taxation does, however, require a great deal of sound judgment, and, when properly balanced, provides an equitable basis for financing. The charges and taxes reflect the increased value of the abutting property, the benefit of actual usage and the general level of sanitation in the community.

Public Authorities in Pennsylvania

By J. Raymund Hoffert

A paper presented on Nov. 4, 1949, at the Chesapeake Section Meeting, Washington, D.C., by J. Raymund Hoffert, Chief Engr., State Dept. of Health, Harrisburg, Pa.

IT has been said that an authority is a means for doing legally that which would otherwise be unlawful. A more correct statement would be that a public authority is an agency through which a government may provide needed services and facilities for its people upon a self-liquidating basis, in the manner of private industry and without obligating the government. The authority is a modern recognition of the fact that providing utility services and facilities is essentially a business function of government and lies in a field of activity in which the direct beneficiaries of the service should pay for its cost in proportion to use, much as they would pay for water, gas, electricity, telephone and similar services. Some qualification of this definition is in order, however, since, as Frederick L. Bird has pointed out, the same general method was used in England 200 years ago to build toll roads, and also because present-day authorities, in Pennsylvania at least, are empowered to build schoolhouses, parks and other utilities for the use of which a governmental agency pays rather than the individual users.

The two most important requirements for an authority are that it shall not pledge the credit of the government creating it and that it shall provide a self-liquidating service, the charges for which shall amortize the original cost and meet all operating expenses, repairs and depreciation, as well as furnishing, usually, some reserve against emergencies.

The development of authorities in Pennsylvania was largely brought about during the late depression as a result of the financial difficulties which municipalities experienced in trying to provide needed services for their people within constitutional debt limitations. As a matter of fact, the great Commonwealth of Pennsylvania, itself, because of its constitutional debt limitation of $1,000,000, created "The General State Authority" on June 28, 1935, with permission to issue bonds for the construction of buildings and facilities which were then rented to state institutions. Similarly, the state's famous turnpike was constructed by the Pennsylvania Turnpike Authority, which is presently extending the eastern and western terminuses of this road to traverse the full length of Pennsylvania. The state has more recently recreated "The General State Authority" with authorization to issue $175,000,000 in bonds, the previous one having passed out of existence. "The State School Building Authority" has also been established for a purpose which is obvious from its title.

At the other extreme of governmental levels is the little borough of

Dillsburg, Pa., which is constructing a sewer system and treatment works under an authority. Between these extremes lies a long list of Pennsylvania authorities, set up under various acts, for such purposes as the construction, improvement or acquisition of water works; the construction of sewerage, school, municipal and factory buildings; and housing, airports, parks, flood control and other projects.

Pennsylvania's first municipal authority act was approved June 28, 1935 (P. L. 463), and subsequently amended in 1937, 1939 and 1943. This act was superseded by the "Municipalities Act of 1945," approved May 2, 1945 (P. L. 382), which expanded and improved the status of municipal authorities. A 1947 amendment still further increased the scope of authorities. Inasmuch as the authorities created under the municipal authorities acts are of the most interest to water works men, these alone will be considered here.

Provisions of Municipalities Act

Under the 1945 act, "municipality" includes any county, city, town, borough or township of the commonwealth, and the authority is empowered to acquire, hold, construct, improve, maintain, operate, own or lease, either as lessor or as lessee, projects of the following kind and character: buildings to be devoted wholly or partially to public uses, including school buildings, and for revenue-producing purposes; transportation, marketing, shopping terminals, bridges, tunnels, flood control projects, highways, parkways, traffic distribution centers, parking spaces, airports and all facilities necessary or incident thereto, parks, recreation grounds and facilities, sewers, sewer systems or parts thereof, sewage treatment works, including works for treating or disposing of industrial wastes, steam-heating plants and distribution systems, incinerator plants, water treatment and supply works, water distribution systems, swimming pools, playgrounds, lakes, low-head dams, hospitals, motor buses for public use within any municipality, and subways.

There is the limitation that: "The purpose and intent of this act being to benefit the people of the Commonwealth by, among other things, increasing their commerce and prosperity, and not to unnecessarily burden or interfere with existing business by the establishment of competitive enterprises, none of the powers granted by this act shall be exercised in the construction, improvement, maintenance, extension or operation of any project or projects which in whole or in part shall duplicate or compete with existing enterprises serving substantially the same purposes."

The authorities are granted and may exercise all powers necessary or convenient for carrying out their purposes. Their existence is limited to 50 years, and the maturity of their bonds to 40 years, with no refunding bonds to have a maturity date beyond the life of the authority. They have power of eminent domain and can file liens for debts owed them, but the obligations of the authority cannot create any obligation upon the part of the government which establishes it. The authorities can also sue and be sued, and the bondholders are given remedies under the act in the event of default.

The details of the act are too voluminous to quote, but from the foregoing it will be seen that an authority is em-

powered to provide almost any non-competitive facility needed by a modern municipality, on a businesslike basis, so long as the authority does not pledge the credit of the municipality creating it.

Following the granting of authority to acquire existing water works, a considerable number of privately owned utilities were taken over by municipal authorities, sometimes under circumstances which raised the suspicion that the erstwhile private owners would, by virtue of a management provision contained in the bill of sale, continue to secure much of the profits of the water works for "management services" without incurring the responsibility for necessary maintenance and improvement. It is of particular interest that of the nearly 200 municipal authorities in Pennsylvania today (about 170 of which are active in some degree), at least 96 were created solely or in part to construct, acquire or improve water works. Only one of the latter has passed out of existence. Most of these 96 were probably set up to acquire privately owned water companies. In addition, a number of the other authorities undoubtedly have general powers including those relating to water works. A number of the authorities were created for the purpose of providing both water and sewerage service. The formation of authorities to acquire water works was brought almost to a standstill, however, by the 1943 amendment to the municipal authorities act, which made it necessary to secure the approval of the public utilities commission before taking over a water property subject to its jurisdiction.

At least 32 of the authorities have been created in whole or in part to provide sewerage, and it is expected that many more will have to be formed before the sewage treatment works required by the Pennsylvania Sanitary Water Board can be constructed. Several of the existing authorities are joint ones, one sewerage authority having thirteen member municipalities. The exact number which will eventually become part of the Allegheny County Sanitary Authority is not known at present, but 95 municipalities are included in its territory. It is reported that there are now in Pennsylvania about 100 additional authorities of one kind or another under consideration or in the process of formation.

Businesslike Administration Required

The Pennsylvania Municipal Authorities' Assn., with an active membership of 44, publishes a quarterly, *The Authority*, in which its activities and the problems and procedures of its members are set forth. Also, at the association's annual meetings, these matters are the subject of well prepared papers and talks. The excellent program of the 1949 meeting well illustrated the field, the problems and some of the sound procedures of municipal authorities. It was made quite plain that an authority is a business venture on the part of the municipality, that it should be conducted in accordance with the same sound principles as a comparable private business, and that it is pretty much subject to the same problems, trials and difficulties as private industry.

It scarcely seems necessary to say that the authority should be created only to supply a bona fide need which will at least outlast the life of the bonds; that the facility or service

should be provided at the minimum cost for the kind and quality of service required; and that the persons to be served must be financially able to pay for the service. All legal verbiage aside, the charges of the authority are a direct additional levy upon the income of the residents of the municipality which created the authority and of any adjacent parties served by it. If these groups cannot meet the cost of the services through tax payments, the creation of an authority will not produce a magic reduction in expense. The authority merely overcomes the limitations upon debt incurred; in fact, the authority bonds will quite frequently command a higher interest rate than the municipality's own general-obligation bonds, thus somewhat increasing the cost of the service. Consequently, regardless of its legal right, an authority cannot as a practical matter issue bonds for a project which is a poor business venture, because they will not find buyers except at a prohibitive cost and upon a speculative basis. A concrete example, and one of the problems facing officials of some of the smaller communities, is the unwillingness of investment firms to underwrite bonds for sewerage projects when the annual rental would exceed about $35 per house connection. Only projects which appear to be financially sound both at their start and throughout their life will interest underwriters and bond purchasers. Hence, the *stability* of income, as well as the authority's rate structure, the merit of its plan and its assets, is of prime importance. A declining community is not a good risk.

Just as a private business commands a good standing only when the management is known for its integrity and ability and its business methods inspire confidence, so too, every authority should be run by men of high moral character and proved business acumen who will be unfettered in the exercise of their abilities and who will devote sufficient time to authority affairs. The quality of management is of especial importance, because one of the arguments cited against authorities is the lessened control which the voters have over the authority board as compared with their control over elected officials. Furthermore, the authority should not only conduct its affairs according to sound business principles, but should fully acquaint its "customers" with its facilities, services, rates, financial structure and methods of doing business, in a manner somewhat similar to the public relations programs of comparable private industries. It should also practice the same courtesies as well conducted private businesses.

Labor Relations

The authority should constantly seek to reduce the cost of its service without impairing its financial integrity or failing to provide adequately for its employees. At the Pennsylvania Municipal Authorities' Assn. meeting in 1949, it was rather freely admitted that the widespread unionizing of the employees of Pennsylvania's authorities was due to the failure to raise wages and salaries until unionization forced their adjustment to the levels prevailing for comparable work in the localities concerned. In one authority, which promptly raised the inadequate wages of the employees when it acquired its property, the unions have made no headway. Although it is generally felt that unionization offers more benefits

to the employees than to the authority, it was also brought out that unionization helps an authority to solve the seniority problem. Public employees in Pennsylvania are forbidden to strike by a statute, arbitration being required in labor-management controversies. This rule applies to the employees of municipal authorities, but all the expenses of arbitration must be borne by the authority.

As with private business, the authorities have the problem of pensions and retirement pay. In Pennsylvania, only a few of the authorities, notably those concerned with water, have retirement plans or contemplate establishing them, but it may be anticipated that pressure for such plans will increase.

Public Relations

It is believed that Pennsylvania authorities are generally meeting with success and are pleasing their patrons. Sometimes rates have been increased to meet increased operating costs or to pay for improvements. Occasionally authorities report that, although there has been no improvement in service, fewer complaints have been received than when the property was under private management, apparently because the customers are more contented under public than private ownership. Some authorities have experienced difficulties, however, and a few have passed out of existence.

One difficulty has been municipal interference with the board of the authority. It need scarcely be said that if any authority is to be successful, the governing body of the municipality must select thoroughly competent men of complete integrity and sound judgment as members of the authority board and must then permit them to operate the authority in accordance with its charter and without hindrance, so long as they are not derelict in the performance of their duty. Disputes between a municipal council and an authority over which of alternate sewerage projects should be adopted led to the resignation of at least one board and of one or more members of another board before the matter was settled and actual construction was begun.

The difficulties and dangers facing an authority which receives only questionable public support from a community of very limited financial strength and uncertain future are well illustrated by the following example. An authority was formed to provide both water service and sewage collection and treatment for a community in a township adjacent to a city which is the county seat. The community was being served with water by the city but there was dissatisfaction with the rates. The authority had well prepared plans drawn for its proposed water and sewage facilities, but, before construction, the city agreed to receive and treat the sewage, thus making it unnecessary for the authority to build a sewage treatment works. The authority then drilled three wells and constructed a pumphouse over each, built a steel water storage tank and laid a transmission main to the community to be served. Because of the wartime shortage of pipe, approximately 1,200 ft. of used pipe had to be employed to make the final connection with the existing distribution system. Then the real trouble began. The new, soft water dissolved the tubercles in the old pipe and red water appeared, so incensing the customers, who were accustomed to the clear city water, that they demanded a return to it.

The result was calamitous. The authority already had on the ground the pipe for its sewers and had laid a substantial part of its interceptor. The authority's financial program had been carefully worked out, but it represented about the total load which the community could carry and even that was possible only if the revenue from the water service helped pay for the sewerage. With the loss of the water rents, the authority's whole project collapsed. The authority went into bankruptcy, its assets were sold at auction and it passed out of existence. Thus ended a brave attempt to provide needed sewerage while at the same time meeting the community's wish to escape from what it felt were excessive rates for its existing water supply. Friction over the appointees to the authority board, together with the small financial resources and the perhaps narrow outlook of the average property holder in the community, made the project somewhat precarious at best. Thus, the failure to convince its patrons that the ultimate advantages would outweigh the temporary inconvience proved fatal to this authority.

Problems and Procedures

Certain procedures of Pennsylvania authorities are rather well known, but some of them, as well as several unique features and problems, may be of interest. For instance, a number of authorities have either acquired or constructed facilities and have then leased them to the municipality, receiving rental therefor which is used to meet the authority's financial obligations. Conversely, authorities have leased municipally owned facilities, such as water works, and are operating them for the municipality. Some municipally owned sewer systems have been turned over to authorities in order to permit a sewer rental to be charged, thus providing revenue for the construction of sewage treatment works. At least one authority, comprising several counties, has been set up with the object of acquiring a number of the water and other utilities serving the communities involved, and perhaps combining them into a single financial structure.

A municipality in one of the anthracite coal fields, confronted with the problem of maintaining employment in the face of the exhaustion of the coal, formed an authority to acquire properties for occupation by industries which could be induced to come there and thus expand the city's industrial life. The charter was so well drawn and so comprehensive that the authority's activities could be expanded to take over utilities. The city has already acquired the privately owned water company, and plans are now under consideration for providing the city with sewage facilities. It is especially noteworthy that, for nine years, the authority paid no taxes on its building, on the ground that it was a public facility. Within the past year and a half, however, the county assessors have levied taxes against the building, and a lower court has upheld their position. The authority has been required to pay the tax on that part of its real estate which is not used solely for public purposes.

A problem for a township authority, set up to serve only a particular district within it, was the question of who becomes the owner of the property after the people of the district have paid for it and the life of the authority has expired. It would seem to be a thoroughly safe assumption that the owner

will be the township as a whole and not just the taxpayers of the particular area served.

Two municipalities which had formed a joint authority, each having equal representation on its board, desired to have the board itself select an additional member to prevent, say, a tie vote. The legality of this procedure was in question, however. It is understood that the appointment of such an additional member is not authorized but that it is sometimes being done to good advantage.

Another problem faced by one of the second-class townships in Pennsylvania was the relocating of its water pipelines, necessitated by a state highway department decision to reroute two of its roads. Not only did this change forestall the use of a plot of ground purchased by the township for an office and administration building, but it also involved an out-of-pocket loss of $17,000 for pipeline relocation, and some years of planning by the township. Inasmuch as the highway department is an agency of the state, the township authorities had no legal redress, but they feel very strongly that a subordinate municipality created by the state should not be penalized by the acts of the state. Although the township recognizes that the highway changes were not made captiously, the supervisors do feel that the township is entitled to some relief.

One of the problems which the smaller municipalities must meet in creating authorities is the careful preparation of the contracts which they make for engineering, legal and other technical services and for plant operation and supervision. A small borough was offered, and had apparently entered into, an agreement under which a certain firm would provide general supervision of and make recommendations regarding the operation of the sewerage system. The firm was to receive a yearly fee, payable semiannually, amounting to 2 per cent of the cost of the sewer system and treatment works. This would have involved a charge of nearly $7,000 a year! It is understood that the contract has since been modified to base the fee on the cost of the plant and interceptor only.

Even the smallest authorities will do well to secure competent and unbiased engineering advice, and frequently such authorities will find it distinctly to their advantage to sell their bonds at private sale, as they are permitted to do under Pennsylvania law, rather than to advertise them for sale. Under the latter procedure, the authority must bear the expenses of attorneys' and bond experts' fees, which are customarily paid by the investment houses when the bonds are sold to them by private agreement under the safeguards set forth in the municipal authorities act.

A nice problem confronting an authority created to construct flood control works arises from the fact that the authority has nothing tangible to sell in order to raise revenue for the project. Those who would benefit from protection against possible future damage must be induced to contract to pay installments permitting the construction. A further complication is involved if there is a difference of opinion on the extent of protection needed.

Another point of genuine interest is that the U.S. comptroller general has decreed that the funds of an authority are not "public funds" and, therefore, a national bank depository does not have to set up a special re-

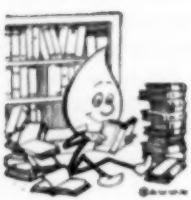
serve in a Federal Reserve bank. Thus, the authority's deposits need now be protected by such a depository only to the extent of the $5,000 federal insurance on deposits.

A particularly significant and important legal decision was handed down in a taxpayer's suit for an injunction restraining the Susquehanna Township (Dauphin County) Authority from constructing its approved sewer system, on the basis of the unconstitutionality of the municipal authorities act on four counts. The lower court refused to issue the injunction and upheld the law. The court's ruling on the four points and its statement that an authority is a "body politic," that a limit *is* placed on the authority's spending, and that the township officials, in the last analysis, made the assessment of costs, is well worth study by those interested in this subject.

Another lawsuit worthy of attention is the Rankin case, in which a taxpayer sought to enjoin the Chester Water Authority *inter alia* from increasing its rates and to compel the refunding of the additional amounts already collected. The Court of Common Pleas found for the defendant authority and this decision was upheld upon appeal to the Superior Court of Pennsylvania.

Conclusion

From the foregoing, it may well be concluded that an authority can be an efficient governmental agency for providing, on a self-liquidating basis, the facilities needed by its citizens for modern living. But the authority must be operated in accordance with the principles of high integrity, good management and sound fundamental economics which are necessary in any private business. Moreover, authorities have certain legal and financial problems not common to private enterprise, in compensation for certain powers which they possess beyond those of private enterprise. Finally, it is evident that authorities cannot "pull money out of a hat" or provide services beyond the ability of the taxpayers to meet the cost.



Research on the Disposal of Radioactive Wastes

By O. R. Placak and R. J. Morton

A paper presented on Oct. 31, 1949, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by O. R. Placak, Scientist, U.S. Public Health Service, Oak Ridge National Laboratory, and R. J. Morton, Supervisor, Waste Disposal Research Section, Oak Ridge National Laboratory, Oak Ridge, Tenn.

THE rise of nuclear fission as an industry has been both spectacular and rapid. A few short years have witnessed the birth of an industry so new, so large and so unique that it is a little difficult to comprehend. Like other large industrial operations, the atomic energy industry is faced with many problems in the disposal of its waste by-products. In many respects, the discarded material may be considered as just another industrial waste which must not be released in such a way that it will become a hazard to life or health, or cause economic damage. But the unique characteristic, radioactivity, on a scale undreamed of before, sets nuclear-fission wastes apart from others. The criteria for their disposal are unknown or unfamiliar to most people.

The knowledge that there are wastes from this industry has been accompanied by speculation on the effect of radioactive waste materials on sanitary engineering facilities, such as water and sewage plants. Feeling on this matter has ranged from an attitude of complacence to one of extreme foreboding. This wide divergence of opinion is a result of the lack, so far, of exact knowledge on which to base authoritative opinions. Considered solely as a peacetime problem, the true answer lies somewhere between these extremes and is perhaps not so bad as the more pessimistic predictions would have one believe.

Because of the health implications inherent in this problem, it should be of interest to everyone concerned with water supplies. It is doubtful, however, that the average water plant will be affected in the near future or for some time to come, but expansion of the industry and increasingly wide use of its products, the radioisotopes, may change this conclusion. Before this development occurs, it is necessary to obtain as much information as possible and be prepared to meet or forestall difficulties. Investigations are already in progress at various sites and institutions throughout the country. A number of organizations are participating in these studies, including, among others, the Atomic Energy Commission, the U.S. Public Health Service, the Tennessee Valley Authority and various educational institutions.

In the discussion that follows, an attempt will be made to give some idea of the problems involved, the investigations being conducted elsewhere and the program at Oak Ridge.

Problems Involved

The inhabitants of earth have always been exposed to low-level radiation due to the cosmic rays and to naturally occurring radioisotopes, approximately 50 of which are known. Men have also been exposed occasionally to a somewhat higher level of radiation, such as that from diagnostic X-rays and shoe-fitting fluoroscopes. This point is mentioned to emphasize that exposure to radiation is not new; it has always been a part of life. The difference is one of degree. There is a certain natural concentration of radioactive materials, varying from place to place, that will always be present and about which nothing can be done. The problem is not to avoid all exposure—that is impossible—but to prevent additional artificial exposure which, when added to the natural radiation, will cause harmful effects.

TABLE 1

Natural Radioactivity in U.S. Waters

Water Source and Location	Radon Activity Concentration $\mu c.^a/ml.$
Curie Spg., Boulder Spgs., Colo.	2.6×10^{-4}
Arapahoe Spg., Boulder Spgs., Colo.	0.6×10^{-4}
Magnesium Spg., Hot Spgs., Va.	9.3×10^{-5}
West Mound Spg., Ponsho, Colo.	7.4×10^{-6}
Hortense Spg., Colo.	6.4×10^{-6}
Hartsel Hot Spg., Colo.	4×10^{-6}
Nauheim, Glen Spg., N.Y.	2.6×10^{-6}
Old Cave Spg., Glenwood Spgs., Colo.	2.2×10^{-6}
Kovarik and McKeehan, Ohio	2.2×10^{-6}
Tioga Mineral Wells, Fitch, Tex.	2×10^{-6}
White Sulphur Spgs., W.Va.	8.6×10^{-7}
Pluto Spg., French Lick, Ind.	4.9×10^{-7}
Old Orchard Mineral Spg., Mo.	4.3×10^{-7}
Clinch R., Norris, Tenn.	$\sim10^{-7}$

[a] Microcuries.

Table 1 gives the concentrations of radioactivity that occur naturally in springs in various parts of the country, some of which have been valued as medicinal waters. The list is by no means complete. In considering this table, it should be borne in mind that the value used at Oak Ridge as a maximum permissible concentration in the Clinch River is 10^{-7} (or 0.0000001) microcurie per milliliter. This value may contain a factor of safety of the order of 100. The inclusion of a factor of safety emphasizes the lack of knowledge about some aspects of this subject and the need for research to obtain that knowledge. The most interesting conclusion to be drawn from

TABLE 2

Relationship Between Half-Life and Grams per Curie

Element	Mass No.	Half-Life *years*	*g./curie*[a]
U	238	4.51×10^{9}	2.93×10^{6}
Pu	239	2.41×10^{4}	15.7
Cs	135	2×10^{6}	7.5
Ra	226	1,622	1
C	14	5,100	0.19
Sr	90	25	6.1×10^{-3}
		days	
Sr	89	53	3.6×10^{-3}
P	32	14.3	3.4×10^{-3}
I	131	8	7.8×10^{-3}
		hr.	
Na	24	14.8	1.1×10^{-7}
A	41	1.83	2.3×10^{-8}
		sec.	
N	16	7.35	1.0×10^{-11}
Th C′	212	3×10^{-7}	5.5×10^{-18}

[a] The values in this table were obtained from the equation, g./curie $= 7.47\times10^{-9}AT_d$, in which A is the atomic weight and T_d the physical half-life in days.

these observations is that it is possible to establish and maintain a radiation tolerance value for the river below a large atomic-energy installation such as Oak Ridge which is lower than the amount of radioactivity in some naturally occurring waters used for their supposed therapeutic value.

Another general concept of importance is the variety and the magnitude of the materials dealt with. In a hospital or a research institution, the number of isotopes used will be limited and so will the quantities involved, but, in an operating uranium pile like that at Oak Ridge, radioisotopes of 30 or 40 elements may be involved. Many of these are rare earths or other elements previously of little concern or even unknown in nature. Among these are yttrium (Y 90, 91), zirconium (Zr 95), columbium (Cb 95), ruthenium (Ru 103, 106), cesium (Cs 135, 137), lanthanum (La 140), cerium (Ce 141, 144), praseodymium (Pr 143, 144), illinium (Il 147), europium (Eu 156), as well as the more common elements, strontium, barium, iodine, antimony, tellurium and iron.

Magnitude of Radiation

In addition to considering the numbers and kinds of elements, their order of magnitude must be appreciated to understand what is involved in this type of research. In terms of radioactivity—that is, curies—very large quantities are involved. In the past 50 years, 1,200–1,500 curies of radium have been isolated. Today, in an operating nuclear reactor, millions of curies are involved. The meaning of these large amounts of radiation may perhaps be better understood in terms of mass units. The relation between mass, activity and half-life (the time in which a radioactive element exhausts half its radioactivity) is shown in Table 2. It is quite evident that equal quantities of radiation may vary by a factor of a million or more in terms of mass and that very large amounts of radiation may represent only small quantities of material.

An example will illustrate what these figures imply in terms of parts per million, a more familiar unit of measurement. One curie of Sr 89, which has a half-life of 53 days, is equal to 3.6×10^{-5} g. Assuming that it is permissible to discharge 1 curie per week into a river, in one year the discharge would amount to $52 \times 3.6 \times 10^{-5} = 187 \times 10^{-5}$ g., or 1.87 mg. If this quantity were discharged into a sizable stream with a flow of 3,500 cfs., it would amount to:

$$\frac{1.87}{3{,}500 \times 0.646 \times 10^{6} \times 365 \times 3.785}$$

or approximately 0.6×10^{-12} ppm.

It is necessary to visualize the small quantities of material that may be involved if a real appreciation of the meaning of research in this field is to be gained.

Some mention should be made of the "indestructibility" of radioactive material. It will not grow or propagate itself like coliform organisms, but neither can it be destroyed as they can, by chlorination. Since it can be neither destroyed nor neutralized, there are only two alternatives for its disposal—concentration and storage or dilution and dispersal. Natural decay (from a few days to thousands of years) will then reduce the radioactivity. In the event of dispersion of radioactive material, consideration must be given to the possibility of sub-

TABLE 3*

Permissible Concentration of Radioisotopes

Isotope	Permissible Concentration in Tissue μc./g.	Maximum Oral Absorption (fraction)	Maximum in Critical Organ		Permissible Concentration—μc./cc.				Effective Half-Life (days)
			Organ	fraction	Inhaled Air (8-hr. Day)		Water	Urine	
					Insoluble Compounds	Soluble Compounds			
Ra	2.8×10^{-6}	0.35	bone	0.99	2.0×10^{-12}	1.3×10^{-12}	1.1×10^{-10}	5.5×10^{-10}	16,000
Proc. U & products	9.2×10^{-6}	0.0005	kidney	0.45	3.5×10^{-10}	1.7×10^{-10}	7.6×10^{-4}	2.6×10^{-7}	5
			lungs		2.1×10^{-11}			3.5×10^{-5}	120
			bone	0.20	1.5×10^{-9}	7.4×10^{-10}	3.4×10^{-3}	5.0×10^{-6}	60
Pu 239	7.9×10^{-6}	0.007	bone	0.75	2.8×10^{-12}	1.4×10^{-11}	4.8×10^{-6}	3.5×10^{-6}	730
P 32	1.2×10^{-3}	0.30	bone	0.48	2.3×10^{-7}	1.4×10^{-7}	1.4×10^{-3}	2.3×10^{-5}	13.2
			muscle	0.25	1.8×10^{-6}	1.1×10^{-6}	1.1×10^{-2}	4.6×10^{-5}	13.8
I 131	3.7×10^{-3}	1.00	thyroid	0.20	4.4×10^{-9}	3.3×10^{-9}	1.5×10^{-5}	1.1×10^{-6}	6.32
S 35	1.5×10^{-2}	0.56	bone	0.34	1.3×10^{-6}	8.8×10^{-7}	5.6×10^{-3}	9.9×10^{-4}	31.3
			liver	0.25	6.5×10^{-6}	4.4×10^{-6}	2.8×10^{-2}	5.6×10^{-3}	2.05
C 14	1.5×10^{-2}	0.30	total body	1.0	1.0×10^{-3}	6.4×10^{-4}	6.3	2.8	0.174
K 42	5.2×10^{-4}	0.90	muscle	0.67	6.6×10^{-6}	3.4×10^{-6}	1.7×10^{-2}	8.4×10^{-4}	0.490
Na 24	3.0×10^{-4}	0.58	total body	1.0	4.5×10^{-6}	3.1×10^{-6}	1.9×10^{-2}	4.0×10^{-4}	0.604
Sr 89	1.5×10^{-3}	0.05–0.60	bone	0.70	7.6×10^{-8}	4.3×10^{-8}	7.4×10^{-4}	2.4×10^{-6}	41.9
Sr 90, Y 90	7.2×10^{-4}	0.05–0.60	bone	0.70	7.8×10^{-9}	4.5×10^{-9}	7.8×10^{-5}	1.2×10^{-5}	196
Ca 45	9.3×10^{-3}	0.90	bone	0.90	5.3×10^{-9}	3.9×10^{-9}	1.9×10^{-4}	2.6×10^{-6}	134

* Adapted from a table prepared by K. Z. Morgan, Health Physics Div., ORNL; to be published by the National Research Council in the *Handbook of Nuclear Instruments and Techniques*.

sequent reconcentration in muds, algae, vegetation and animal life.

Permissible Concentrations

The ideal goal of the AEC is that no radioactive contaminants shall be discharged to nature. Because in practice, this would be difficult if not impossible of accomplishment, some permissible figure that will be safe must be decided upon. The values in use at the Oak Ridge National Laboratory are as follows: for a beta or gamma emitter, the maximum permissible concentration beyond the area of control is 10^{-9} microcuries per cubic centimeter in air and 10^{-7} in water; for an alpha emitter, the figure is 5×10^{-12} in air and 10^{-7} in water.

These values may contain a factor of safety of 100. So far as is now known, no provable harm to humans could occur if they were exposed to these conditions for a lifetime. The tolerance value for beta and gamma emitters applies to mixed fission products. For each individual isotope, a different value might apply. Some theoretical values are shown in Table 3. The exact limits of tolerance cannot be given with absolute certainty until more biological and physiological data are obtained. A reassuring statement should be made, however. If the tolerance values in use are in error, they are probably on the conservative side. It is thought that, for many of these materials, more than 100 times the amounts listed might be ingested, provided it were a single occurrence with no subsequent exposure.

Technical Difficulties

Some mention might be made of the technical difficulties encountered. Radioactive materials increase the time required to set up and perform an experiment because every precaution must be taken to assure that no hazard exists. This statement is particularly true at higher levels of activity. Careful planning and forethought are needed to make sure that working areas are not contaminated nor personnel overexposed and that the waste material is disposed of in a safe manner. Then too, there is, as yet, no body of standard procedures, so that most investigations branch out incidentally into a study of procedures and techniques. The development of special instruments is often necessary as well.

It is especially important to beware of generalizations in this field. For example, it is possible to determine the efficiency of removal of a given mixture of fission products from water by standard water purification processes, but to apply this result to all contaminants would be a dubious procedure. A considerable share of the removal might be due to adsorption by the coagulant—approximately 90 per cent if the waste were predominantly cesium, but only about 20 per cent if it were chiefly strontium.

A certain amount of background material has been presented to indicate that work in this field, in relation to water and sewage research, will entail all of the difficulties previously present plus many new ones. As a redeeming feature, radioisotopes provide a usable analytical tool which is much more sensitive than was thought possible until recently.

Scope of Research

The scope of research on the waste disposal problem, as visualized at the Oak Ridge National Laboratory, may

be indicated by the following outline:

Group A—fundamental research to obtain detailed knowledge of the behavior of radioactive materials in air, water, soil, plants, animals and man:

1. Meteorological research.
2. Geological research.
3. Research on the gross behavior of radioactive materials in drainage systems, soil and plant life, under conditions of discharge from ORNL and similar plants. (A study of water filtration and sewage disposal plants is included.)
4. Specific behavior of individual elements, such as plutonium, polonium, uranium and certain beta and gamma emitters.
5. Effects of radioactive materials on fish and animal life.

Group B—development of methods of preventing radioactive materials from producing damage to man, animals or plants:

1. Control at source. (At ORNL, it is anticipated that the technical problems involved will be attacked principally by the Technical Div.)
2. Removal of radioactive materials from water supplies.
3. Removal from air by means of masks, filters and the like.
4. Decontamination of persons, clothing, equipment and buildings.
5. Methods of detection and survey under conditions of warfare.
6. Methods of purging radioactive substances from interior of body.

This outline is currently being used as the basis for planning in the Health Physics Div., which is primarily interested in Group *A*, although it is expected that any knowledge obtained will be applied to items listed in Group *B*, so far as manpower and facilities permit. It is anticipated that Item 6 of Group *B* may receive the attention of medical and biochemical groups elsewhere. The above outline is very broad, of course, and a large number of specific projects are planned in many of the categories.

Research Groups

It has been indicated that the determination of permissible limits for radioactive contamination is of primary importance. The National Committee for Radiation Protection, which has been in existence since 1928, has added several new subcommittees in this field. Two of these, the Subcommittee on Permissible Internal Dose and the Subcommittee on Waste Disposal and Decontamination, are very active and will influence research on these subjects. Both committees are engaged in analyzing existing data and in formulating recommendations therefrom. Both, also, are pointing out the places where information is lacking or dubious and are encouraging research in these areas. The findings of the Subcommittee on Permissible Internal Dose should provide information on the criteria to be met. The investigations of the other subcommittee are expected to result in rules under which research can be carried on in these fields. A third group, the Subcommittee on Safe Handling of Radioisotopes, has almost completed its work and will shortly publish recommendations. It would be impossible to overemphasize the work of these committees.

In addition, numerous other projects are being carried on which will add to the knowledge of the influence

of radioactive materials on sanitation. All of the AEC installations are engaged in pertinent research, either on waste disposal or on environmental effects, or both. At Los Alamos, N.M., in cooperation with the U.S. Public Health Service, the removal of plutonium by activated sludge systems has been studied, and other means of removal, using essentially a sanitary engineering approach, are being investigated. A fairly comprehensive program, in cooperation with outside agencies, is under way at Oak Ridge. This project will be discussed in more detail later. Other studies, notably at Hanford, Wash., are being conducted on the environmental effect of radioactive materials. The U.S. Public Health Service, in addition to its cooperative work, has an investigative program of its own.

The AEC subsidizes a number of unclassified research projects, which, directly or indirectly, should furnish valuable information to water and sewage works officials. Results should soon be available, and anyone interested in these projects may find complete listings in the semiannual reports of the AEC. New York University, for instance, has a contract to study waste disposal in sewers. Johns Hopkins is investigating the adsorption and assimilation of radioactive materials by bacterial slimes, and Massachusetts Institute of Technology will do research on radioactive-waste removal by water treatment processes.

Health Physics Div. Research

The program of waste disposal studies in the Health Physics Div., Oak Ridge National Laboratory, is a cooperative project. Participating agencies are the ORNL, the U.S. Public Health Service, the Tennessee Valley Authority and the Oak Ridge office of the AEC. Very recently waste disposal has been declared an unclassified area of research, so that, with a few exceptions, it will be possible to publish whatever information is obtained.

At ORNL, a natural subdivision of responsibilities has occurred. The Technical Div. is charged with the development of methods for the control of the waste materials at the source, while the Health Physics Div. is responsible for those wastes which must be discarded or which escape after treatment within the plant. In general, this research involves large volumes of materials with relatively low radioactivity, which may need further decontamination. There are three general areas of study:

1. *Survey type studies* to define the situation in the vicinity of Oak Ridge —and, by extrapolation, elsewhere— with special reference to the travel of released materials, their reconcentration in mud, algae, fish and other materials, and their effect on environment in general.

2. *Process studies,* including laboratory and pilot plant studies on water, sewage and waste treatment processes. Such investigations are of public health significance in that they will make it possible to determine the effects of radioactive materials upon sanitary engineering works and processes. A corollary objective is the determination of the effectivness of these processes as waste treatment procedures.

3. *Corollary studies,* including the development of instrumentation and techniques, as well as cooperative efforts in conjunction with geological, meteorological and ecological programs.

The breakdown of these general statements into specific items may be illustrated by listing some current projects:

1. *Survey type studies:*

a. Collection, assay and analysis of fish from White Oak Lake

b. Periodic sampling of water, mud and algae from White Oak Creek and the Clinch River

c. Preliminary work on the exposure of fish and algae to radioisotopes under semicontrolled conditions

d. Descriptive analyses of the time of water and wave travel in the Clinch River from Norris Dam to White Oak Creek and below

2. *Process studies:*

a. Water decontamination experiments to determine efficiency and adsorption factors

b. Preliminary studies of slimes in sewage using a contact aerator, to determine buildup of slime, absorption of radioactivity and effect on removal from waste mixtures

c. Study of characteristics and efficiency of various ion-exchange materials in the removal of mixed fission product wastes

d. Adsorption of radioactive materials by natural clays and other finely divided suspensions or coagulant aids

3. *Corollary studies:*

a. Assay and counting methods—treatment of samples and preparation for counting

b. Special study of technical problems involved in assaying, such as self-absorption, uniform distribution of samples and loss on evaporation

c. Surface water survey instruments for water and mud scanning

d. Continuous water and waste monitoring (gamma and hard beta radiation) by conventional methods, and the study of proposals for telemetering, recording and alarm systems at White Oak Dam.

Conclusion

It is sometimes difficult to judge, at a given moment, how much progress is actually being made, but the outlook is optimistic. Given a little time, these problems will be resolved just as others have been in the past. Chlorination of water was practiced for many years before the fundamental mechanism involved was really understood. In the field of radioactive waste disposal, it is believed that understanding will proceed more rapidly, because everyone concerned is very conscious of the problems involved and a concerted effort is being made to solve them.

Illegal Demands on Water Department Funds

By J. E. Gotherman

A paper presented on Nov. 4, 1949, at the Ohio Section Meeting, Dayton, Ohio, by J. E. Gotherman, Deputy Supervisor, State Auditor's Office, Columbus, Ohio.

IT may be stated generally that the use of water works funds, resources or assets for any purpose not specifically authorized by the constitution of Ohio, statutory law and municipal charter provisions is illegal. It should be noted further that municipal water works funds and resources can only be used for municipal and public purposes.

The authority for municipal ownership and operation of public utilities is found in Art. 18, Sec. 4 and 5, of the Ohio constitution. Section 6 of Art. 18 restricts the amount of surplus utility products which may be sold and delivered to those outside the corporate limits of the city or village to 50 per cent of the total service or product supplied by the utility within the municipality.

Section 12 of Art. 18 authorizes municipalities to issue and sell mortgage bonds beyond the general limit of bonded indebtedness prescribed by law. Sections 3619 to 3619–4, General Code, authorize municipal corporations to provide for a supply of water and to issue and sell mortgage bonds for the purpose of financing the cost of a municipal water works. Sections 3955 to 3981 of the General Code, inclusive, prescribe the manner in which municipalities shall provide for a water supply through municipal ownership and operation of a water works.

When the rules laid down in the state constitution and statutes are followed, the question of illegal use of water works funds and assets does not arise. Because of local pressure on public officials for additional services, and the need for increased revenue with which to finance them, water works funds are sometimes illegally diverted to furnish a part of the extra cost of local government.

It should be stated at this point that illegal demands on water department funds may be classified as "direct" and "indirect." Some examples of the "direct" type of illegal demand or diversion of water department funds are given below.

Direct Demands

1. The purchase of fire hydrants from water funds is illegal for the reason that such hydrants are not appurtenances of the water works but are installed primarily for the protection of property from fire hazard.* Therefore, the expense of purchasing and installing fire hydrants is a proper charge to the safety department appropriation in the general fund. If hydrants have been installed outside the corporate limits of the municipality for the protection of surburban property, the municipality may not legally expend water works or other municipal

* This is an Ohio concept, not commonly held in other states.—*Ed.*

funds to maintain and keep them in repair.

2. The erroneous classification of employees in other departments as water works employees for payroll purposes is sometimes done in order to tap water works funds for general operating expenses. Obviously, such procedure is illegal and has been so ruled by the attorney general in many cases.

3. Excessive charges for the rental of office space used for water works purposes are sometimes made in order to increase revenue to the general operating fund. In one Ohio city, the water department was charged $20,000 a year for this item, although comparable space in the same general location was renting for approximately $5,000 at that time. The attorney general, in Opinion No. 6769, rendered March 27, 1944, ruled, in part, that: "A municipality may, consistent with Sec. 3959, General Code, and pursuant to the provisions of Sec. 280, General Code, out of the revenues of its water works pay into the municipal treasury the reasonable value of office space and heat and light therefor, furnished to the water department by the city, such expenditures being a part of the necessary expense of conducting and managing the water works." It was apparent in the case cited that the charges were in excess of the "reasonable value" of such office space. There have been other instances in which the same principle was involved, but in a lesser degree.

4. Free service may be authorized by the city council in accordance with the provisions of Sec. 3982-1, General Code, when the water is used for a municipal or public purpose. Care must be exercised, however, in determining what constitutes a municipal or public purpose within the meaning of the statute. It has been ruled that water may *not* be furnished free of charge to churches, parochial schools, the Y.M.C.A., the Boy Scouts or other privately controlled religious, charitable or fraternal organizations.

5. Although interfund borrowing is illegal in Ohio, many attempts have been made to borrow from the water fund for other municipal purposes. Notes issued for such purposes are unauthorized by law, and any transfer of water funds by this means is illegal. It should be borne in mind, when surplus funds are used to purchase bonds issued by the municipality, that such investments must be made in full compliance and conformity with provisions of Sections 4296-1 to 4296-4, General Code, inclusive. Failure to do so can and does result in the loss of water department funds.

Indirect Demands

Some of the "indirect" illegal demands upon water department funds are more difficult to detect. Large amounts of revenue may be lost through the absence of a carefully planned and properly executed administrative policy for the water department. In the author's opinion, the best insurance against this condition is 100 per cent metering of services and the maintenance of perpetual inventory records, plus a system of internal checks and balances designed to reveal, through periodic reports and analyses, any unusual deviation or discrepancy between the amount of water pumped, the amount metered for sale and the revenue derived therefrom. Also, any irregularities noted in the inventory of parts, materials, tools or equipment should be carefully investigated.

Recently the examination of water department records in one Ohio city

disclosed the sale, by a former employee, of several hundred dollars' worth of pumping equipment, motors and pipe to a local junk dealer for $75. Needless to say, the equipment was recovered for the city. The records of the state auditor's office disclose many similar instances, and it is certain that there are many more which were not uncovered by the examiners because of the lack of proper inventory records.

The value of water lost through undisclosed leaks, defective installations and faulty meter registration amounts to thousands of dollars annually in the municipal water departments of Ohio. In one city, such errors on five large industrial accounts totaled $2,457, the largest single error being $1,071.29. All of the above amounts, and many smaller sums, were collected as the result of the disclosure of errors by one examination. Another city lost $1,262.80 through the installation of "standby" service for an industrial plant from a fire line because the connection was not metered or adequately controlled by water department employees.

In still another city, a large industrial corporation was furnished water service through a 4-in. meter which stopped and was permitted to remain out of order over a period of several years. An authentic estimate of water consumed during the period was prepared from information obtained from reliable sources, and a bill was rendered the industrial firm for 11,708,408 cu.ft. of water, valued at $8,756.43. The finding was promptly paid by the company when the matter was called to the attention of the accounting department.

It has been found that new services are often installed without notifying the accounting division of the water department, with the result that such services are furnished free over long periods. One outstanding example is recalled in which a private club received free water, heat and gas at the expense of the water department for several years. An examination disclosed that the estimated free service amounted to $1,300.60. A finding was rendered against the private club in favor of the city, and a settlement was obtained.

The only exception to the general rule against the diversion of water department funds to other funds and purposes is found in the provisions of Sec. 3959, General Code, which permit the transfer of a portion of the surplus to the sewage disposal or treatment fund, under certain conditions:

1. The sewage disposal or treatment plant and the water system must be operated as a single unit under one operating management.

2. There must be a surplus in the water department fund after paying the expenses of conducting and managing the water works, providing for their repair, enlargement or extension, and meeting the interest on any loan made for construction or for the creation of a sinking fund to liquidate the water works debt.

3. If it is established that a surplus exists, a sum equal to 5 per cent of the gross revenue of the preceding year mst be deducted as a reserve for water works purposes.

After providing for all of the previously listed requirements, a sum amounting to 10 per cent of the gross water revenue for the preceding year may be used to pay the cost of maintenance, operation, repair, enlargement and replacement of the sewerage system and sewage pumping, treatment and disposal works.

Pennsylvania's Clean-Streams Program

By Howard E. Moses

A paper presented on Sept. 14, 1949, at the Pennsylvania Section Meeting, Harrisburg, Pa., by Howard E. Moses, Cons. Chief Engr., State Dept. of Health, Harrisburg, Pa.

IT is perfectly obvious that any improvement of the sources of public water supplies will be of distinct advantage both to the people and to the water purveyor. The greater the pollution load imposed upon sources of supply, the more difficult is the task of the water works man to produce a consistently safe and acceptable product. Accordingly, it may be of interest to review briefly the statewide program of the Pennsylvania Sanitary Water Board for stream pollution control and to appraise its value to public water works.

Stream pollution control is especially pertinent in Pennsylvania because the majority of the large public water supplies are secured from surface streams. Hence, anything which harmfully affects the commonwealth's streams is of direct importance to the various uses to which a stream may be put. The superior use is that of public water supply, but animal and aquatic life, industrial water supply and recreation must also be considered. It is fair to state that, if a stream can be put into suitable condition for public water supply use, it is generally suitable for any other use. This assertion may seem contrary to existing conditions, since grossly contaminated streams are often used for public water supply by purifying them to assure that the water is at least safe, if not otherwise acceptable from the standpoint of appearance, tastes and odors, and perhaps other characteristics. Such a supply is not a good one, however, and is probably being used because none better is available.

Pennsylvania is plentifully supplied with streams, it being estimated that there are 100,000 miles of named streams in the commonwealth, ranging from the uncontaminated woodland rivulets to the great rivers draining vast areas. There are six principal drainage basins: the Delaware River, to the east, drains 14 per cent of the state's area; next to it, to the west, the vast Susquehanna River Basin drains 47 per cent; and beyond that is the Ohio River Basin, which drains about 36 per cent of Pennsylvania; there are also three smaller basins, the Genesee to the north, the Potomac to the south and the Lake Erie watershed to the northwest.

These main rivers and their tributaries drain the 45,000 square miles of Pennsylvania territory, in which reside approximately 10,000,000 people. Pennsylvania has nearly 1,000 incorporated municipalities, together with many densely populated areas outside them. All of the cities, most of the larger boroughs and many of the township communities have public sewer systems, through which enormous quantities of untreated sewage are contributed to the waters of the state. Although there are approximately 300

sewage treatment works, these in general are not found in the larger communities, where the great bulk of the sewage originates. In addition, many industrial wastes are discharged directly to streams.

Eighty per cent of the population of the state is furnished with public water supplies, mainly from the Delaware and Ohio River watersheds. Interestingly, the principal streams of the Susquehanna River Basin are but little used for public supplies, although draining one-half the state's area.

The Genesee and Potomac River Basins are unimportant from a water supply standpoint, although some of the streams in the latter are utilized for this purpose. On the Lake Erie watershed, the city of Erie and its satellite communities are furnished with water taken from the lake, and the other communities in this basin use tributary streams.

In the Delaware River Basin, however, the story is quite different. Approximately 2,320,000 people are supplied with water taken from the Delaware and Schuylkill Rivers. A similar situation is present in the Ohio River Basin. Both the Allegheny and the Monongahela Rivers, which unite to form the Ohio, are utilized for public water supplies to a large extent. In the Pittsburgh metropolitan area, for example, approximately 1,596,000 inhabitants rely exclusively on the streams of this watershed for the source of their public supply. The pollution of these waters is, therefore, a factor of extreme importance.

Types of Pollution

The two main types of pollution are sewage and industrial wastes. The principal contributors of sewage are the municipalities, from whose sewer systems millions of gallons of untreated sewage are poured daily into the waters of the state. Sewage is not only a filthy and loathsome material degrading the receiving body of water, but is also dangerous to public health because of its disease-producing ability. In the past many epidemics of typhoid fever and dysentery were chargeable to the infection of public water supplies by sewage, and the main reason for the comparative rarity of such outbreaks today is the effectiveness of water purification. Typhoid fever is not an extinct disease, however, but merely a controlled one, and outbreaks can again occur either through accident or as the result of careless operation of purification plants. Accordingly, any measures taken to decrease the pollution load from sewage will at the same time reduce the hazards existing wherever water is taken from a sewage-contaminated stream.

The other principal pollutant is industrial waste. In the highly industrial state of Pennsylvania, these wastes are of great volume and variety. Certain poisonous wastes are a distinct menace to those who must use water containing them, while other types of waste bring about such a deterioration in the stream as to render it almost unusable. Fish and other aquatic life are destroyed, and all use of the stream for recreation is blocked. The important part played by industrial wastes in stream pollution was not recognized by legislators until lately, but now serious efforts at control are being made throughout the entire country.

The severity of this problem in Pennsylvania is evident from a consideration of the various kinds of industrial wastes discharged into the streams. The chief waste products are those from milk plants, distilleries,

steel works, mines, metallurgical establishments, pulp and paper mills, quarries, canneries, gas works, textile mills, abattoirs and rendering plants, by-product coke works and chemical industries, oil wells, refineries and tanneries.

Many of these industries are scattered quite generally throughout the state. Others of a particular type are more or less localized, such as the steel industries in western Pennsylvania. Mining in its various forms is probably the most widespread, with the anthracite industry in the eastern part of the state and the bituminous covering a vast area in the west central and western end.

In general it may be said that the greatest concentration of industry is on the watersheds of the Delaware and the Ohio Rivers, which are likewise the streams most used for public water supplies.

It is quite pertinent to consider the possibilities of treatment of the two principal types of wastes. For many years much attention has been given to practical methods of treating sewage, and such methods are fairly well known. Within the last ten or fifteen years new processes have been developed, and those already known have been expanded, modified or made more adaptable to present-day needs. A distinct tendency in recent years has been the mechanization of sewage treatment plants. In effect, this field has been measurably developed and there are now a number of well tried methods from which to choose with reasonable assurance of successful results when properly applied.

The same fortunate situation does not exist with regard to industrial wastes, due in part to the rather late start of the intensive study of this matter now being made. In general, the designing engineer knows fairly well how to provide primary treatment for most of the industrial wastes but is unable to proceed with the same certainty in furnishing higher degrees of treatment. This difficulty is not universal but does apply to certain types of industries. Rapid strides are being made in this field, however, and research is under way which is developing greater knowledge of the problem and is providing the engineer with means of combating this widespread menace to state waters. Many plants for the handling of industrial wastes have already been built and are rendering good service. Industry has awakened to the fact that it can no longer shirk its responsibility to protect the waterways and, through its studies and experiments, is finding methods of providing such protection, often with profit.

Clean-Streams Program

Coincident with the creation of the Pennsylvania Dept. of Health in 1905, a pollution control act was passed giving it jurisdiction over the discharge of sewage into state waters. In 1937 a more comprehensive act was passed, including both sewage and industrial wastes, which conferred rather sweeping powers upon the Pennsylvania Sanitary Water Board and provided stiff penalties for infractions. In 1945 the sections of the act relating to industrial wastes were amended, the board being granted more power and the penalties increased.

A most significant feature of these new laws was the definite change in the conception of the use of a stream. Prior to 1937 greatest emphasis had been placed upon the use of a stream for domestic water supply, but in that year the term "pollution" was redefined and the idea of clean and unclean

streams was established. Pollution was defined as meaning noxious and deleterious substances rendering unclean the waters of the commonwealth to the extent of being harmful or inimical to the public health, or to animal or aquatic life, or to the use of such waters for domestic water supply, industrial purposes or recreation.

There was formerly a more or less passive toleration by the public of stream pollution, unless the public water supplies were seriously affected. Today, however, the people are not only demanding emphatically and consistently that they be furnished a safe and acceptable water supply but at the same time they are insisting on clean streams which must have a good appearance and be suitable for bathing, fishing and other forms of recreation. This demand has been upheld by court decisions establishing the right of the people to have their streams preserved against all other considerations.

The sanitary water board in 1944 undertook an accentuated program of stream pollution control, applied on a statewide basis. The bureau of sanitary engineering made a careful appraisal of the streams and presented the board with a tentative classification. The board then proceeded with a series of ten hearings, held throughout the commonwealth, to which were invited all persons interested in the matter. At these hearings, the board explained in detail its purpose and aims and announced a proposed policy of stream pollution control: all sewage must be treated "at least to a primary degree," with such additional treatment as might be required in individual localities; and an equivalent degree of treatment would be required of industrial wastes.

Subsequently, the board began the issuance of notices to municipalities and to polluting industries requiring the preparation and submission of plans for treatment works, the degree of treatment being specified in each instance. Generally a period of one year was granted in which to comply with the board's order. To date 559 notices have been issued to muncipalities and 662 to industries.

To implement this feature of the program, the health department was empowered by law to make grants-in-aid to municipalities, not to exceed 50 per cent of the cost of plan preparation, and money for this purpose was appropriated in 1945. Up to the present $750,712.41 has been distributed.

Not until recently did these notices carry an order for construction of the treatment works, except in critical situations. Because of the high costs and the confusing condition of the construction field, the board deemed it unwise to call for the building of these plants on a statewide scale. During 1949, however, the board adopted a different policy for the watershed of the Delaware River and is now notifying all municipalities and polluting industries in that entire region, including the Schuylkill River drainage area, to undertake construction of treatment works, which are to be completed within approximately two years. There were special considerations which dictated such action, especially in the Schuylkill River Basin, where a state-federal desilting project is well under way.

This comprehensive order has not been extended throughout the rest of the state, but it is likely that the sanitary water board will in due time proceed along the same line on the other watersheds.

Several notable examples of accomplishment may be cited. All of the collieries at the headwaters of the Schuyl-

kill River have installed plants for the retention of silt resulting from the processing of coal, and today thousands of tons of this material which formerly would have been discharged to state waters are being retained. Philadelphia is spending approximately $60,000,000 for projects providing for the collection and treatment of its sewage. One of three immense treatment works is well along toward completion, and contracts for units of the other two have already been made. In the Pittsburgh metropolitan area a sanitary authority has been created for all of Allegheny County, and plans to provide for the collection and treatment of the sewage of 106 municipalities in that important area are well advanced. Other district projects are under consideration, with detailed plans for treatment works in various stages of development.

The bureau of sanitary engineering has been working in close cooperation with both municipalities and industries. Numerous conferences have been held with representatives of some of the main industries, such as milk, pulp and paper, steel and oil; and standards of quality have been adopted in several of them and are being studied in others preparatory to acceptance.

Research projects for the sanitary water board are being carried on by the Mellon Institute, for the study of acid mine drainage, and by the Pennsylvania State College, which is attempting to find a satisfactory and reasonably inexpensive method for handling wastes from slaughterhouses. The Academy of Natural Sciences of Philadelphia made an intensive survey of Conestoga Creek to determine the relation between wastes and aquatic life in the stream. A special study was made of the Clarion River, now subjected to heavy pollution, principally by industrial wastes.

Phenol and its compounds, when discharged into waters used for public supply, have an immediate and far-reaching effect, producing unusually obnoxious tastes and odors and giving rise to widespread complaints by consumers. The sanitary water board adopted a resolution, applying at present only to the Ohio River Basin, prohibiting the discharge of any wastes of this character into state streams. This action is particularly important in Pennsylvania because of the presence of a number of by-product coke plants and chemical industries which produce such wastes. The board has also acted in situations involving the treatment of poisonous wastes such as cyanides and has erected an absolute prohibition against the discharge of these wastes in harmful form.

Conclusion

Many of the items briefly mentioned are interesting stories in themselves, but the conclusion to be drawn is that Pennsylvania is awake to the need for protecting its streams, which constitute one of its most valued resources. Pennsylvania was the first state to undertake this important work on such a comprehensive scale, and its efforts are being closely observed, with many of the other states falling in line. There is convincing evidence that the plan adopted by Pennsylvania is a reasonable and practical one and that it can be made effective. The accomplishments thus far attained augur well for the ultimate success of this endeavor. The cooperation given by municipalities and by industry appears sincere and heartening. Finally, and of great importance, the public has become stream pollution conscious and is demanding that clean streams be kept clean and those now contaminated be improved.

Developments in the Chlorine Dioxide Process

By R. N. Aston

A paper presented on Sept. 15, 1949, at the Pennsylvania Section Meeting, Harrisburg, Pa., by R. N. Aston, Sales Development Dept., Mathieson Chemical Corp., Niagara Falls, N.Y.

THE chlorine dioxide process has now been in commercial use for more than five years since the first installation at Niagara Falls in 1944. The process has steadily grown in favor and is now employed in approximately 120 plants in the United States and in Canada. Originally the process was developed and installed for the control of tastes and odors due to the phenolic contamination of water supplies. It has since been applied successfully to other taste and odor problems, such as those caused by algae, decayed vegetation, weeds, sewage, and various types of industrial pollution. Aided by research in both laboratories and water plants, other factors of importance have been developed in the use of the process. For example, the effectiveness of chlorine dioxide as a bactericide is enhanced by its persistence in the distribution system. It is also useful in the removal of iron, manganese and, occasionally, organic color.

It should be clearly stated that, although the use of chlorine dioxide has expanded and its applications are still growing, it does have its limitations and is by no means a "cure-all" for water problems. The only way that it can be successfully evaluated for a particular problem, however, is to try it on a plant scale, which can be done quickly, easily and at little or no cost.

Some current developments in the chlorine dioxide process will now be discussed. Two papers of considerable significance have recently been published on the disinfectant properties of chlorine dioxide. The first of these, by Ridenour and Armbruster (1), shows that a 0.1-ppm. OTA residual of chlorine dioxide will destroy the common water pathogens, including *Escherichia coli*, with a five-minute contact period at temperatures of 5°–20°C. and at all pH values above 7. From these results, it appears that approximately the same residuals are required for disinfection with chlorine dioxide as with free chlorine, on an OTA basis (2). This conclusion has been borne out by a plant scale study at Niagara Falls. For over two months chlorine dioxide alone was used successfully for the disinfection of the raw water. In addition, previously reported data (3) from the Chicopee, Mass., treatment plant, where chlorine dioxide has been used for several years, have shown a marked reduction in the bacteria count of the final effluent. It must be understood, however, that, because of other considerations, including economic factors, the employment of chlorine dioxide as the sole bactericidal agent is not being advocated.

In the second paper, Ridenour, Armbruster and Ingols (4) have indicated that chlorine dioxide is a more effective sporicide than chlorine, if

the two are compared on an equal OTA basis.

Chlorine Dioxide Determination

A simple method for determining chlorine dioxide in water has been the object of a widespread search. Chlorine dioxide present in treated water cannot be distinguished from free chlorine by the conventional OTA test. One-fifth of the total available chlorine present as chlorine dioxide will show in the OTA test as free chlorine. For example, 1 lb. of technical sodium chlorite applied to 1 mil.gal. of water, assuming no chlorine dioxide demand, will give 0.20 ppm. available chlorine as chlorine dioxide in the water. An OTA test would then show 0.04 ppm. as chlorine dioxide in the absence of free chlorine. It has been demonstrated in company laboratories, and amply proved by Ingols and Ridenour (5), that the standard orthotolidine used will show one-fifth of the available chlorine of the chlorine dioxide in the flash OT test or in the standard OTA test. Although the chlorine dioxide process is successfully employed in well over 100 plants, no completely satisfactory method has been available for the simple determination of chlorine dioxide residuals in water. As in other taste and odor control processes, the dosage used has depended on a critical examination of the treated water by the operator.

A method of determining chlorine dioxide has been developed and reported by Haller and Listek (6) which employs an amperometric titration. Although this method has aided the development of the process immeasurably, it has not proved to be a means of control but is more suitable as a research tool or for use in a large plant where a trained chemist is available to run the determinations.

A. T. Palin (7) has recently reported an adaptation of the OTA method using ammonium chloride to react with the free chlorine, thus leaving chlorine dioxide in the sample which could be measured by the OTA test. Following the procedure outlined in this paper, however, did not give consistent results in the company laboratories. The ammonium chloride failed to tie up the free chlorine as a chloramine sufficiently to prevent a partial flash OTA reading, thus interfering with the chlorine dioxide determination.

The company's application research laboratories, working along the lines indicated by Palin, have lately developed an adaptation of the OTA test which appears promising. Past experience with chlorine dioxide has shown that it will not react with oxalic acid, even though the latter is quite easily oxidized to carbon dioxide and water. The fact that chlorine will oxidize the oxalic acid, however, suggests its use to tie up the chlorine in the sample under examination, leaving only the chlorine dioxide to be measured by the OTA test.

A standard solution of chlorine in doubly distilled water was prepared. Chlorine was added up to 1 ppm. flash residual, as measured by the standard OTA test. When tested with the oxalic acid modification, the chlorine was completely tied up and did not show any flash residual which could be mistaken for chlorine dioxide. To a sample of the same chlorine solution, 0.5 ppm. available chlorine as chlorine dioxide was added, and the standard OTA test indicated approximately 1 ppm. total available chlorine as chlorine plus one-fifth of the chlorine dioxide. The oxalic acid–OTA test was then made, tying up the chlorine and leaving only the chlorine dioxide,

which then measured 0.1 ppm., exactly one-fifth of the chlorine dioxide known to be present. Thus, the chlorine in the solution did not interfere with the determination.

Next a group of stable standard solutions of chlorine dioxide in doubly distilled water was prepared in a range of 0.25–1.75 ppm. total available chlorine in water which had no chlorine residual. These samples were checked first with the regular OTA test and then with the oxalic acid adaptation. The two series of readings were well within the range of experimental error.

Another group of samples, containing both free chlorine and chlorine dioxide, was made up and tested by means of both the amperometric titrator and the OTA–oxalic acid method. The agreement between the two methods was again well within the limits of experimental error, indicating that the oxalic acid–OTA method could be successfully used.

A number of determinations were then made on samples of tap water at the Niagara Falls water plant. Free chlorine, chlorine dioxide and chloramine were all present. One operator ran the titrator, while another made the oxalic acid–OTA determinations on samples taken simultaneously. The results once more fell within the range of experimental error, recognizing the limitations of the OTA test in measuring low residuals. Work was also done to determine the effect of temperatures and the reaction time of the oxalic acid on the tests. As a consequence of this work, the following procedure can be recommended.

As in the usual OTA test (8), first a determination for interfering substances is made. The total orthotolidine value is also determined, which will include interfering substances, free chlorine, chlorine dioxide and chloramine. Then, in the normal procedure, to one sample is added a dropperful of orthotolidine, followed in five seconds by 1 ml. of 0.1 *N* arsenite solution. The result will include interfering substances, free chlorine and one-fifth of the available chlorine of the chlorine dioxide.

To another sample of standard size is added 1 ml. of saturated cp. oxalic acid solution (about 20 per cent, in distilled water). The mixture is allowed to stand for at least ten minutes to tie up the free chlorine in the sample. The orthotolidine is then added, followed in five seconds by the arsenite. The reading will measure the chlorine dioxide and interfering substances. If it is desired to express the total available chlorine content of the chlorine dioxide, this result must be multiplied by five. It is recommended, however, that the chlorine dioxide be expressed directly in terms of OTA readings, because, as previously noted, for bactericidal purposes the recommendations are based on OTA residuals.

It must be recognized that this test has the same limitations as the usual OTA method. When reading low residuals—that is, those less than 0.1 ppm.—a difficulty may arise because most standards available are graduated from 0.0 to 0.5 and then jump to 0.10. A set can be obtained, however, from 0.02 to 0.10 in 0.02 gradations if greater accuracy is desired in these low ranges.

Although the company's laboratories have checked this test as thoroughly as possible, it is obviously new, and the author would appreciate comments from those using it.

Point of Application

In some areas, the water supplies show a widely varying demand for chlorine dioxide because of a rapidly changing pollution load. Usually chlo-

rine dioxide has been applied to the finished water, unless, of course, iron or manganese presented a problem. At times this procedure has made the control of tastes and odors more difficult, and it has recently been found best to apply chlorine dioxide to the raw water, together with the usual method of chlorination. The dosage at this point depends on the plant retention period and may be held close to the demand for chlorine dioxide. Then, with a point of posttreatment available, additional chlorine dioxide may be applied if the initial treatment falls short of complete taste and odor removal.

This practice may actually result in a more economical treatment, as it eliminates the necessity for operating with a large excess of chlorine dioxide when only one point of application is available. Experience has shown that pretreatment with chlorine dioxide, particularly in conjunction with some form of chlorination, either marginal or free residual, does not markedly increase the demand for chlorine dioxide, as was initially expected.

The author believes that the oxalic acid–OTA method makes it possible to obtain closer control. Where, for example, phenolic tastes are a problem, the maintenance of a chlorine dioxide residual will prevent a phenol taste in the treated water. Because the reaction between phenol and chlorine dioxide is quantitative and rapid, one or the other may remain after treatment, but not both.

Summary

Chlorine dioxide treatment has made considerable progress in the five years of its use and can now be regarded as an established process. It is not a "cure-all," but has demonstrated its value sufficiently to warrant consideration by treatment plant operators.

The process is relatively easy to install and its cost is usually equal to or cheaper than that of other methods in use for taste and odor control. Chlorine dioxide has the ability to handle taste and odor problems due to many causes, such as phenolic or other industrial wastes, sewage, algae and decomposed vegetation. The process is easy to operate and does not require special laboratory control. Its bactericidal properties are equal to or better than chlorine against numerous organisms found in water, as demonstrated by both laboratory and plant experience. It can be used as an aid in maintaining an active chlorine residual in the distribution system, thus keeping up the quality of the water delivered to the consumer.

References

1. Ridenour, G. M. & Armbruster, E. H. Bactericidal Effect of Chlorine Dioxide. Jour. A.W.W.A., **41**:537 (June 1949).
2. Butterfield, C. T. Bactericidal Properties of Free and Combined Available Chlorine. Jour. A.W.W.A., **40**:1305 (Dec. 1948).
3. Aston, R. N. & Synan, J. F. Chlorine Dioxide as a Bactericide in Water Works Operation. J.N.E.W.W.A., **62**: 80 (March 1948).
4. Ridenour, G. M.; Ingols, R. S. & Armbruster, E. H. Sporicidal Properties of Chlorine Dioxide. Wtr. & Sew. Wks., **96**:279 (Aug. 1949).
5. Ingols, R. S. & Ridenour, G. M. Chemical Properties of Chlorine Dioxide in Water Treatment. Jour. A.W.W.A., **40**:1207 (Nov. 1948).
6. Haller, J. F. & Listek, S. S. Determination of Chlorine Dioxide and Other Active Chlorine Compounds in Water. Anal. Chem., **20**: 639 (July 1948).
7. Palin, A. T. Chlorine Dioxide in Water Treatment. J. Inst. Wtr. Engrs. (Gt. Br.), **2**:61 (1948).
8. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).

The Optimum Incubation Temperature for the Primary Isolation of Coliform Organisms

By Joanna R. Boniece and W. L. Mallmann

A contribution to the Journal by Joanna R. Boniece, Section of Bacteriology, Michigan Agricultural Expt. Sta., East Lansing, Mich., and W. L. Mallmann, Prof. of Bacteriology and Public Health, Michigan State College, East Lansing, Mich.

THE optimum temperature for the growth of *Escherichia coli* as well as other members of the coliform group has been considered to be 37°C. It is recommended in *Standard Methods for the Examination of Water and Sewage* (1) that the incubation temperature for the bacteriological analysis of water samples should be 35°–37°C. The question arises whether the optimum temperature for the growth of coliform organisms in their normal habitat is also the optimum growth and fermentation temperature after these organisms have existed in water for some time at temperatures normally much lower than 37°C.

A review of the literature reveals no attempts at incubation at temperatures lower than 37°C. in the presumptive test for the bacteriological examination of water samples. Some investigators, however, have tried primary isolations at temperatures as high as 46°C. For example, Minkevich (2), in applying the principle of Eijkman's fermentation test (3–5) for determining the "coli titer" of water, found that, at temperatures of 46°, 45°, 44° and 43°C., maximum dilutions of sewage-polluted water and suspensions of coliform cultures are not always able to ferment manitol, being inhibited more by the higher temperatures. Nevertheless, Minkevich and his coworkers concluded that 43°C. was the highest temperature harmless for coliform organisms in "maximum dilutions" of water samples, although higher fermentation titers were obtained when 37°C. incubation was used.

Other investigators, unlike Minkevich, employed pure cultures of intestinal organisms isolated from various sources in testing the efficacy of temperatures higher than 37°C. for the primary isolation and detection of organisms of fecal origin. Sherwood and Clegg (6, 7) contended that the most reliable test for the detection of *"Bacterium coli"* was incubation in MacConkey's broth at 44°C. Experimental results obtained with pure cultures of organisms from shellfish, sewage and feces were offered in support of their argument. Conclusions drawn from experimental results obtained with pure cultures grown at normally optimum temperatures are, however, not necessarily valid for the primary isolation or detection of these organisms after they have existed for some time in a suboptimum temperature environment.

Intestinal organisms that survive for extended periods in water at tempera-

tures usually much lower than 37°C. conceivably might become so adapted to those lower temperatures that a relatively sudden return to the temperature of their normal environment could seriously impair their ability to survive and multiply. Therefore, this investigation was undertaken to determine the optimum temperature for the primary isolation of coliform organisms from water.

A further impetus to this study was provided by the adoption of 35°C. incubation for the bacteriological examination of milk by *Standard Methods for the Examination of Dairy Products* (8). Because many laboratories use the same incubator for the incubation of water and milk samples, it would be desirable to have one incubation temperature for both types.

TABLE 1

Comparison of Various Incubation Temperatures for Esch. coli*

Time hr.	Incubation Temperature—°C.			
	32	35	37	39
	Log Avg. Counts			
0	1.78	1.79	1.81	1.80
2	2.44	2.63	2.77	2.65
4	3.73	4.30	4.63	4.74
6	5.36	5.85	6.33	6.34
8	6.65	7.41	7.72	7.82
12	8.31	8.63	8.57	8.61
24	8.80	8.72	8.57	8.51

* Four cultures, nine runs.

TABLE 2

Comparison of Various Incubation Temperatures for Aer. aerogenes*

Time hr.	Incubation Temperature—°C.			
	32	35	37	39
	Log Avg. Counts			
0	1.77	1.74	1.75	1.76
2	2.33	2.53	2.63	2.94
4	3.98	4.35	4.48	4.54
6	5.36	6.35	6.31	6.32
8	6.93	7.67	7.64	7.62
12	8.47	8.51	8.13	8.31
24	8.89	8.71	7.42	7.20

* Four cultures, nine runs

Experimental Procedure

Temperatures of 32°, 35°, 37° and 39°C. were selected for study. Four specially constructed incubators, each with a capacity of 1 cu.ft., were used. These incubators were carefully controlled to maintain the desired temperature within ± 0.5°C.

The first phase of the study involved growth curve determinations at the above four temperatures for representatives of the coliform group. All of the organisms thus studied had been isolated in pure culture from various water sources. It should be emphasized that, since the initial isolation of these organisms, all subcultures had been incubated at 37°C.

The organisms used in the growth rate studies were *Escherichia coli* (four cultures), *Aerobacter aerogenes* (four cultures) and *Intermediate I* (five cultures).

Cultures were carried on plain nutrient agar slants. Uniform saline suspensions of the organisms were made from 18- to 24-hour single-strength lactose broth cultures which had been incubated at 37°C. The saline suspensions were so diluted that when 1 ml. of a suspension was added to 99 ml. of single-strength lactose broth in an

Erlenmeyer flask, the number of organisms per milliliter present in the flask did not exceed 100. The flasks were shaken by machine for five minutes to insure uniform distribution of the organisms. From each broth culture thus prepared, 15-ml. aliquots were pipetted into each of four sterile test tubes. After plating out 1 ml. from each flask to determine the initial counts, the tubes were distributed among the four incubators set at 32°, 35°, 37° and 39°C. At the end of 2, 4, 6, 8, 12 and 24 hours, 1-ml. aliquots from each tube were plated in appropriate dilutions with tryptone glucose extract agar. All plates were counted after 48 hours' incubation at 37°C.

At the same time 1-ml. aliquots from the 15-ml. portions of the broth cultures were added to each of four Dunham single-strength lactose fermentation tubes, which were then incubated with the other cultures, one at each temperature. Gas production in per cent was recorded for each incubation temperature after 12, 24 and 48 hours.

To obtain representative results, 29 such determinations were made. Each culture was run at least two times. Following the accepted procedure for handling such data, the logarithmic average counts were determined for each coliform type. The data are presented in Tables 1–3.

From a study of the logarithmic growth rates for both *Esch. coli* and *Aer. aerogenes*, it is evident that the optimum growth temperature for these organisms must lie in the 37°–39°C. range, since the growth rates for each of these two organisms are practically the same for the two temperatures. There appears, however, to be no marked decrease in the growth rates of either *Esch. coli* or *Aer. aerogenes* when they are incubated at 35°C.

Also it is apparent that the optimum growth temperatures for *Intermediate I* is quite definitely close to 35°C., even though the organism is only slightly retarded by a temperature of 32°C. On the other hand, incubation at 37°–39°C. appreciably decreases its rate of growth, as is obvious from the much lower bacterial populations at the stationary phases for those two incubation temperatures.

TABLE 3

Comparison of Various Incubation Temperatures for Intermediate I*

Time hr.	Incubation Temperature—°C.			
	32	35	37	39
	Log Avg. Counts			
0	1.70	1.71	1.70	1.69
2	2.12	2.21	2.23	2.15
4	3.51	3.52	3.15	3.02
6	4.71	4.92	4.41	4.07
8	6.07	6.43	5.54	5.33
12	8.02	8.17	6.61	6.55
24	8.71	8.61	7.17	6.24

* Five cultures, eleven runs.

The second phase of the study pertains to the actual isolation of coliform organisms from samples of various types of contaminated water. All samples were properly collected and refrigerated until tested. No samples were held more than 24 hours.

A four-tube presumptive test was performed on every sample at each of the four incubation temperatures. In every test, 10 ml. was added to each of two double-strength lactose broth fermentation tubes, and 1.0 and 0.1 ml. were added, respectively, to two single-

strength lactose broth fermentation tubes. All tubes were examined for gas production, which was recorded in per cent for each positive tube at the end of 12, 24 and 48 hours.

Isolations of the coliform organisms were made by streaking Levine's E.M.B. agar from those tubes showing gas production after 48 hours for each sample. After 24–48 hours' incubation at 37°C., discrete suspect colonies were picked from each E.M.B. agar plate and transferred to plain agar slants. The lactose-fermenting ability of each culture was verified before checking for the Imvic reactions. As recommended by *Standard Methods* (1), Kovac's (9) modification of the indol test, Barrit's (10) modification of the Voges-Proskauer reaction and Koser's (11) procedure for the citrate test were used. Whenever the Imvic reaction tallied − + + + or + + + +, the purity of the cultures responsible was checked. Altogether only three types of intermediates were isolated: those giving − + − +, − + + + and + + + + Imvic reactions, respectively. The water samples were classified by the type or types of coliform organisms found in them.

Table 4, which presents a classification of the samples based on the type of organisms isolated, indicates the number of tubes showing gas. From the 147 samples, more tubes showing gas were obtained at 32° and 35°C. than at 37° or 39° C. The total number of positive tubes for each type of coliform organism follows the same pattern.

TABLE 4

*Effect of Incubation Temperatures on Total Number of Tubes Showing Gas for All Water Samples**

Coliform Organism(s) Isolated	No. of Samples	Incubation Temperature—°C.											
		32			35			37			39		
		Incubation Period—*hr.*											
		12	24	48	12	24	48	12	24	48	12	24	48
		Number of Tubes Showing Gas											
Esch. coli	39	7	49	89	15	65	86	7	42	64	16	47	68
Aer. aerogenes	62	22	75	148	30	107	151	21	73	101	30	92	123
Esch. coli & Aer. aerogenes	23	6	35	57	10	38	49	11	31	39	15	38	45
Intermediate I	15	2	17	28	5	19	32	3	19	23	6	20	25
Esch. coli & Intermediate I	2	1	2	3	1	2	4	0	0	2	1	2	3
Aer. aerogenes & Intermediate I	3	0	2	7	1	5	6	0	9	2	0	4	5
All three types	3	1	3	6	2	2	7	3	4	4	2	4	7
Total	147	39	183	338	64	238	335	45	169	235	70	207	276

* Maximum of four tubes per sample at each temperature.

The number of positive confirmed samples, classified by types of organisms, is shown in Table 5. Out of 147 positive samples, 145 were positive at 35° C., whereas only 123 were positive at 37°C.

Since the total number of tubes show-

ing gas in all samples proved to contain coliforms is appreciably greater at both 32° and 35°C. than at 37° or 39°C., it is evident that the optimum or critical temperature for the primary isolation of coliform organisms from water is lower than the temperature of their normal environment. Furthermore, it appears that the best temperature for the primary isolation of coliforms from water is closest to 35°C., since the greatest number of tubes showed gas after 24 hours' incubation at this temperature. These observations are further substantiated by a consideration of the number of confirmed positive samples. Although 32° and 35°C. incubation produced the same number of confirmed positive presumptive tests after 48 hours, again 35°C. seems to be the best, as the most positives after 24 hours were recorded for that temperature.

The data indicate the undesirability of subjecting both *Esch. coli* and *Aer. aerogenes* to a relatively sudden return to the temperature of their normal environment after those organisms have sojourned for some time in water at temperatures far below the normal optimum. There was a striking correlation of the total number of tubes showing gas, the total number of positive presumptives and the incubation temperature, the closest correlation existing at 32° and 35°C. It would appear that the normal optimum temperature (37°C.) often has a definitely harmful influence upon the ability of certain coliform organisms to survive and multiply when it is applied for their primary isolation from water. The data obtained for those water samples from which only intermediates were isolated are also suggestive of this viewpoint although not so conclusively, since relatively few such samples were encountered in the series tested.

TABLE 5

Effect of Incubation Temperatures on Number of Samples Giving Positive Presumptive Tests

Coliform Organism(s) Isolated	No. of Samples	Incubation Temperature—°C.											
		32			35			37			39		
		Incubation Period—*hr.*											
		12	24	48	12	24	48	12	24	48	12	24	48
		Number of Positive Samples											
Esch. coli	39	6	30	38	12	36	38	6	26	34	11	29	36
Aer. aerogenes	62	15	47	62	22	59	62	16	44	53	22	51	59
Esch. coli & Aer. aerogenes	23	5	21	23	9	20	22	10	17	18	9	19	22
Intermediate I	15	2	12	14	3	14	15	3	11	13	5	13	14
Esch. coli & Intermediate I	2	1	1	2	1	1	2	0	0	1	1	2	2
Aer. aerogenes & Intermediate I	3	0	2	3	1	3	3	0	0	1	0	3	3
All three types	3	1	3	3	1	1	3	3	3	3	1	3	3
Total	147	30	116	145	49	134	145	38	101	123	49	120	139

Conclusions

1. The normal optimum growth temperature for *Esch. coli* and *Aer.*

aerogenes is in the 37°–39°C. range.

2. The normal optimum growth temperature for *Intermediate I* is approximately 35°C.

3. The most favorable incubation temperature for the primary isolation of coliforms from water is 35°C.

4. Incubation at 32°C. for primary isolation is also superior to 37°C., although a longer incubation period is necessary at 32°C. than at 35°C.

References

1. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).
2. Minkevich, J. E. et al. The Application of the Principle of Eijkman's Fermentation Test for Determining the Coli Titer of Water. J. Hyg., **36**:50 (1936).
3. Eijkman, C. Die Gärungsprobe bei 46° als Hilfsmittel bei der Trinkwasseruntersuchung. Centr. Bakt., Abth. I, Orig. **37**:742 (1904).
4. Thomann, J. Zum Nachweis des *Bacterium coli* commune in Wasser vermittels der Eijkmannschen Methoden. Hyg. Rundschau, **17**:857 (1907).
5. Fromme, W. Über die Beurteilung des Colibakterienbefundes in Trinkwasser nebst Bemerkungen über den Nachweis und das Vorkommen der Colibacillen. Z. Hyg., **65**:251 (1910).
6. Clegg, L. F. & Sherwood, H. P. Incubation at 44°C. as a Test for Faecal Coli. J. Hyg., **39**:361 (1939).
7. Sherwood, H. P. & Clegg, L. F. Further Studies of Incubation at 44°C. as a Test for Faecal Coli. J. Hyg., **42**:45 (1942).
8. *Standard Methods for the Examination of Dairy Products.* Am. Public Health Assn., New York (9th ed., 1948).
9. Kovacs, N. Eine vereinfachte Methodes zum Nachweis der Indol-bildung durch Bakterien. Z. Immunitätsforsch., **55**: 311 (1928).
10. Barrit, M. W. The Intensification of the Voges-Proskauer Reaction by the Addition of Alpha-Naphthol. J. Path. Bact., **42**:441 (1936).
11. Koser, S. A. Utilization of the Salts of Organic Acids by the Colon-aerogenes Group. J. Bact., **8**:493 (1923).

Methemoglobinemia and Minnesota Well Supplies

By H. M. Bosch, A. B. Rosenfield, Roberta Huston, H. R. Shipman and F. L. Woodward

A paper presented on Sept. 8, 1949, at the Minnesota Section Meeting, Minneapolis, Minn., by H. M. Bosch, Chief, Section of Environmental Sanitation; A. B. Rosenfield, Director, Div. of Maternal and Child Health; Roberta Huston, Asst. Public Health Engr.; H. R. Shipman, Assoc. Public Health Engr.; and F. L. Woodward, Director, Div. of General Sanitation; all of the State Dept. of Health, Minneapolis, Minn. Certain charts, tables and references in the original manuscript have been omitted to conserve space.

IT has been known for some time that the ingestion or absorption of various drugs such as sulfonamides, nitrobenzene compounds, acetanilid, bismuth subnitrate, sulfates, nitrites and chlorates is capable of producing a cellular type of methemoglobinemia (1–6). The characteristic symptom is a grayish blue or brownish blue cyanosis which begins around the lips, spreads to the fingers and toes and to the face, and eventually covers the entire body. This type is acquired, in contrast to congenital idiopathic (no outside causative agent) methemoglobinemia, of which fifteen proved cases have been reported. When no toxic agent could be detected in the acquired type, it was usually spoken of as idiopathic cyanosis.

In 1945 Comly (1) discovered the etiologic factor in two Iowa infants about one month old who otherwise would probably have been considered as cases of idiopathic cyanosis. Interestingly enough, the father of the first infant pointed out the answer by suggesting the possibility of a peculiar reaction between the well water and the soy bean preparation used in the baby's formula, producing a poison which caused the condition. The open-mindedness of the admitting physician to a "cock and bull" theory led to analysis of the well water, which showed a high nitrate content. Thus the etiologic process was discovered.

Following Comly's report of two proved and seven suspected cases from rural Iowa, Faucett and Miller reported three cases in Kansas, and Ferrant two in Belgium. Since then cases have been reported from rural Manitoba, Ontario, Saskatchewan, Illinois, Nebraska, Michigan, Indiana and several other states. New York State reported its first two cases in July 1949. The condition, therefore, is apparently widespread in the United States and Canada.

Medical Aspects

The first case of methemoglobinemia in Minnesota was reported in January 1947, from the community of Tyler, in southern Minnesota. Since then, a total of 139 cases, including fourteen

deaths, has been voluntarily reported to the Minnesota Dept. of Health (methemoglobinemia reports are not mandatory).

As physicians in Minnesota became more familiar with this condition, methemoglobinemia was considered more often in differential diagnosis, which was evidenced by frequent requests for methemoglobin determinations in infants and for analyses of suspected farm wells. Doubtless many mild cases which cleared up promptly were never reported. Familiarity with this condition by physicians as well as rural parents has apparently been responsible for a markedly decreasing incidence of reported cases in 1949, totaling twelve up to August 1.

TABLE 1

Seasonal Occurrence of Methemoglobinemia, 1947–48

Month	Cases			
	1947	1948	Total	*per cent*
Jan.–Mar.	11	9	20	18.7
Apr.–June	19	15	34	31.8
July–Sept.	12	13	25	23.4
Oct.–Dec.	13	15	28	26.1
Total	55	52	107	100.0

Before discussing the findings, it might be well to point out the distribution of cases in this series. As can be seen from the spot map of Minnesota in Fig. 1, practically all of the cases have occurred in the southern half of the state and most of them in southwestern Minnesota. There have been no reported cases in the northern half of the state.

The incidence of cases of methemoglobinemia varied from month to month. In 131 of 139 reported cases with reliable date of onset, the highest incidence, 18, occurred in June and October; the lowest, 6, in November. The 8 cases omitted above were seen by physicians between 1941 and 1947 before this study began, which accounts for the lack of data.

There is a marked difference in the incidence, by quarterly periods, of the 107 cases in 1947 and 1948 during the study (Table 1). The lowest number occurred in the January-March quarter, amounting to 18.7 per cent; the largest number, during the April-June quarter, with 31.8 per cent. The actual percentage of births in Minnesota by quarters was 24.0, 24.3, 26.6 and 25.1. Of the 139 reported cases, 80 were males and 59 females.

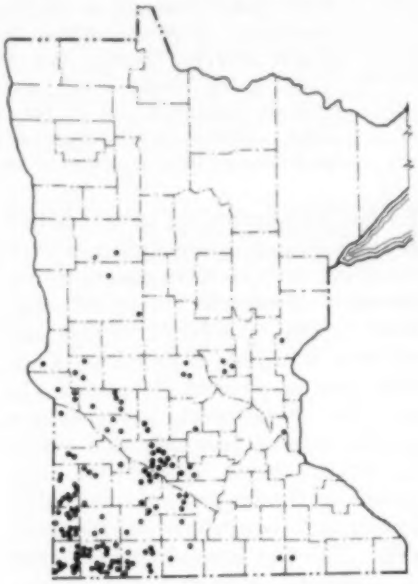


FIG. 1. Distribution of Methemoglobinemia Cases

The age at onset of symptoms in almost 50 per cent of the cases was be-

tween two and four weeks; in 70 per cent, between two and six weeks; in 90 per cent, under two months; and in only 9 per cent, between two and five months. The youngest case was eight days old, and the oldest five months. There were 21 infants who were breast fed for a variable period of from one to four weeks before being changed to a formula containing well water. These infants, therefore, developed symptoms at an age from one to four weeks later than those not breast fed.

The number of days the infant was on well water before symptoms developed (Table 2) depended on the nitrate nitrogen in the water, the amount of water in the formula, the amount of feeding, supplemental water feeding, the length of time the water was boiled, various physiologic considerations and probably other, unknown factors.

TABLE 2

Exposure to Suspected Well Water Before Onset of Symptoms

No. of Cases*	No. of Days Before Onset
1	1
16	2–6
27	7–14
21	15–21
10	22–30
19	over 30

* In 45 cases this information was not available.

Half of the 94 cases for whom this information is available developed symptoms in one to three weeks after being on a formula requiring considerable water as a diluent. Twenty per cent of the infants were on well water more than 30 days, the longest period being 60 days. The shortest period before symptoms developed was 1 day, involving an evaporated-milk formula diluted with water which had been boiled for over 30 minutes, so that the original nitrate nitrogen content of 140 ppm. was concentrated almost threefold (410 ppm.) by evaporation of the water. This fact was demonstrated in a laboratory test on a sample of water from the well involved.

The infant formulas used (Table 3) are of special interest. Evaporated and powdered milk, which require large amounts of water as diluent, were used in 75 per cent of the 86 cases for which this information was available. Diluted cow's milk was used in slightly less than 25 per cent. No cases occurred among infants in this group who were breast fed, with only one possible exception.

TABLE 3

Infant Formulas in Methemoglobinemia Cases

Type of Milk in Formula	Cases*	
	No.	*per cent*
Evaporated	35	41
Powdered	31	36
Cow's	20	23
Breast fed	0	0

* Other cases did not report formula used.

The diagnosis of methemoglobinemia may be presumptive or absolute. In either event, however, it must first be suspected. A presumptive diagnosis may be made if, on removal of venous blood for a hemoglobin determination, the blood is chocolate colored and if there is more than 10–20 ppm. of nitrate nitrogen in the water used in the formula. If the blood is not examined, a presumptive diagnosis is justified if there is a spontaneous disappearance of cyanosis in 24–48 hours after changing the water in the formula and the nitrate

nitrogen content of the water used exceeds the suggested maximum of 10–20 ppm. Whichever basis is used, the history and physical findings should be typical. An absolute diagnosis is made by demonstrating a definite methemoglobin line on spectroscopic examination or by the chemical analytic method of Evelyn and Malloy.

In the eight cases shown in Table 4, the diagnosis was confirmed by methemoglobin determinations according to the method of Evelyn and Malloy, using an electric colorimeter which was transported to the bedside of the patient. Facilities for methemoglobin determination were not available in the rural areas where cases occurred. The readings varied from a low of 0.35 g. per 100 ml. of blood two days after hospitalization to a high of 4.95 g. per 100 ml.

Treatment usually consisted of changing the water in the formula to an approved municipal supply, with prompt recovery resulting. In severe cases, more active treatment became necessary. A 1 per cent methylene blue solution, 1–2 mg. per kilogram of body weight, given intravenously, may be life saving. Its use in nine cases was followed by prompt recovery, the cyanosis clearing up in less than half an hour.

In the 139 cases reported, there were 14 deaths, a mortality rate of 10 per cent. No specific treatment was used in the fatal cases since either the condition was not recognized or methylene blue solution was not readily available. In Minnesota during 1947 and 1948, fifteen infant deaths were reported as due to hypertrophy of the thymus, four of which were actually deaths from methemoglobinemia. Many cases of cyanosis in early infancy in rural areas have probably been incorrectly treated for hypertrophy of the thymus in the past.

TABLE 4

Methemoglobin Determinations

Methemoglobin in Blood *g./100 ml.*	Nitrate Nitrogen in Well Water *ppm.*	Time on Formula *days*	Formula (With Well Water)	Age at Onset *days*
0.355	66	19	SMA	24
0.65	40	11	Evapd. milk	25
0.97	100	49	Biolac	56
0.985	140	1*	Evapd. milk	64
2.5	73	20	SMA	31
3.00	110	47	SMA plus Biolac	58
3.05	110	20	¾-dild. cow's milk	36
4.95	500	9	½-dild. cow's milk	45

* Water boiled for more than 30 minutes.

Discussion

Why only young infants, usually under two months of age, and not older members of the family or even other infants, develop cyanosis is a difficult question to answer. A number of infants stricken with cyanosis had brothers or sisters, a year or two older, who were fed on a similar formula, using water from the same well, but who

failed to develop the condition. Older children and adults, drinking the same water, are not affected. Is this a new disease, or was it unrecognized previously?

that the infant has less oxidizable hemoglobin than an adult. Other factors suggested are: that there is a high fluid intake with greater turnover of water in proportion to body weight;

TABLE 5

Wells Involved in Methemoglobinemia Cases

Physical Features	Nitrate Nitrogen Concentration*—*ppm.*							
	10–20		21–50		51–100		Over 100	
	Dug	Drilled	Dug	Drilled	Dug	Drilled	Dug	Drilled
Location								
Satisfactory	1		5		15		13	
Unsatisfactory			18	1	29	2	32	1
No data	1		1		7		3	
Construction								
Curbing:								
Wood			6		15		13	
Concrete tile	1		11		27		26	
Rock or brick			3				3	
Metal				1		2		1
No data	1		4		9		6	
Platform:								
Wood	1		22		37	2	40	1
Concrete					6		5	
Metal					1			
None				1				
No data	1		2		7		3	
Depth—ft.:								
Under 20			3		3		4	
20–40	1		6	1	19		17	
40–60			5		2		6	
60–75			1		5		3	1
75–100					4	1	2	
100–150			1		1		1	
Over 150					1	1		
No data	1		8		16		15	

* No wells contained less than 10 ppm.; average concentration was 102.0 ppm.

According to Comly (1), there are a number of factors which make an infant more susceptible to nitrate cyanosis than older persons. The most important single factor, in his opinion, is that the intestinal flora may contain more nitrite converters; that the infant's intestinal mucosa is more easily damaged and favors absorption of nitrites; that the limited excretory power

of the infant's kidney may favor nitrogen retention; and that nitrate ions may be more firmly bound by infantile hemoglobin because of the immaturity of certain enzymes.

According to Ferrant, nitrates in well water are probably more toxic for newborn infants than for adults, especially if the infants have digestive disorders, which may be a factor as 14 per cent in this series had diarrhea. Cornblath and Hartmann (*2*), however, claim that only younger infants develop methemoglobinemia, upon ingestion of water containing nitrates, because of the low gastric acidity characteristic of the neonatal period. As a result of experimental work, they postulate that, if there is no free acid in the stomach and the pH of the gastric juice is over 4.0, nitrite-producing organisms can exist high in the gastrointestinal tract in sufficient number to reduce nitrates to nitrites before the former can be completely absorbed. In their control group of infants, in which the gastric acidity was increased by lactic acid milk feeding, they were unable to produce methemoglobinemia with mixtures containing high-nitrate water. This explanation appears to be reasonable. In three cases of methemoglobinemia in this reported series, the pH was 4.5, 5.0 and 5.5, respectively. There are undoubtedly, however, other factors involved, and all these theories are debatable.

Water Supply Aspects

Nitrate determinations on samples from water supplies were made in the earlier days of the Minnesota Dept. of Health but were gradually discontinued with the advent of modern bacteriological methods. The health department's interest in the nitrate concentrations of water supplies in the state has been renewed, however, since the first suspected case of methemoglobinemia was reported at Tyler in January 1947, and the water supplies involved in the cases reported subsequently have been investigated. In addition, studies have been made throughout the state on municipal and private supplies.

A study of the nitrate nitrogen concentration of the wells involved was begun in June 1947. Physicians and mothers cooperated in the areas under observation by reporting past and present cases. In January 1949 a communication was sent to all physicians in the state asking them to report any suspected case of methemoglobinemia that had come to their attention in the past several years. The physicians were also asked to notify the department immediately of any new cases.

In the 139 reported cases, 125 dug wells and 4 drilled wells were involved, eight of these in two or more cases. Two wells caved in before samples were obtained. The detailed data on the 129 wells examined are given in Table 5.

None of the wells contained less than 10 ppm. nitrate nitrogen, and only two (1.5 per cent) contained from 10 to 20 ppm. Insufficient clinical data were available on both of these cases, so that they are considered questionable. The samples from many of the 25 (19.4 per cent) which contained 21–50 ppm. were collected a year or more after a methemoglobinemia case had occurred, and sometimes the well had been abandoned subsequent to the illness. The lowest nitrate nitrogen in a sample collected at the time of the infant's illness was 36 ppm.; the highest was 500 ppm. The average concentration of all the wells suspected of occasioning methemoglobinemia was 102.0 ppm.

None of the wells was both located and constructed satisfactorily, as judged by the standards of the Minnesota Dept. of Health. (These standards for safe water supplies specify that a well should be located at least 50 ft. from all sources of contamination, such as barnyards, privies and the like. The well should be provided with a watertight casing which extends at least 10 ft. below and 1 ft. above grade. A reinforced concrete platform extending at least 2 ft. from the well casing in all directions should cover the well. A tight seal at the pump base and a stuffing-box head on the pump are also specified. Pit construction is not approved.)

Of the dug wells, 34 were located satisfactorily, whereas all 4 drilled wells were located unsatisfactorily. A total of 70 wells were located within 50 ft. of a source of animal contamination (barnyard, hogpen and so on), and 13 within 50 ft. of a source of human contamination (privy or cesspool). No data were obtained on 12 supplies.

Wood curbing was used in 34 wells, concrete tile in 55. All but 13 of the 116 wells on which data were obtained had wooden platforms. Depths ranged from 9 to 209 ft. in both the drilled and the dug wells, with one-third between 20 and 40 ft. deep. Coliform organisms were present in 45 of the 51 bacteriological samples taken.

Three southwestern Minnesota counties—Nobles, Chippewa and Kandiyohi—from which cases of methemoglobinemia had been reported, were chosen for more extensive surveys. In two of these counties, Nobles and Kandiyohi, the water supplies of the rural schools and the nearby farms were investigated to determine whether any difference occurred in the nitrate nitrogen concentration in the farm well as compared with the much better located school well. One southeastern county, Olmsted, was surveyed to find if any appreciable nitrate nitrogen concentrations existed in well waters in that county, although no cases had been reported from that section of the state.

Digest of Data Obtained

A compilation was made of all the water supply data obtained in the school-farm surveys and the methemoglobinemia cases. Of the 389 wells investigated, 244 (63 per cent) were dug, 125 (32 per cent) drilled, and 20 (5 per cent) driven. A total of 206 wells, more than 60 per cent of which were drilled, contained less than 10 ppm. nitrate nitrogen. Of the remaining 183 wells, 23 contained between 10 and 20 ppm.; 43, between 21 and 50 ppm.; 66, between 51 and 100 ppm.; and 51, over 100 pm. All but 16 of these 183 wells were dug.

Of the 389 wells investigated, 188 were located satisfactorily. Fifteen of the 188 were also constructed satisfactorily. Twelve other wells were constructed satisfactorily but were located within 50 ft. of a source of contamination. Of the satisfactorily constructed wells, all were drilled; only three contained over 10 ppm. nitrate nitrogen; two of the wells were also located satisfactorily.

Of the 283 wells on which data were available, 169 (60 per cent) were less than 60 ft. in depth. Fifty-five (60 per cent) of the 91 wells containing over 100 ppm. nitrate nitrogen were less than 40 ft. deep.

Periodic Sampling

Municipal supplies. During this study 28 (5.4 per cent) of the 514

municipal supplies in the state were found to contain over 5 ppm. nitrate nitrogen; 16 (3.1 per cent) of these contained 10 ppm. or more. The highest concentration was 27 ppm., in a dug well used as the source for municipal supply in the section of the state from which most of the methemoglobinemia cases have been reported. The health officer of this community has advised all residents not to use the water for infant formulas, and no cases of methemoglobinemia have been reported from this supply. Eight supplies, ranging in nitrate nitrogen concentration from 5 to 27 ppm., were selected for biweekly sampling, which was begun in February 1949. Samples were col-

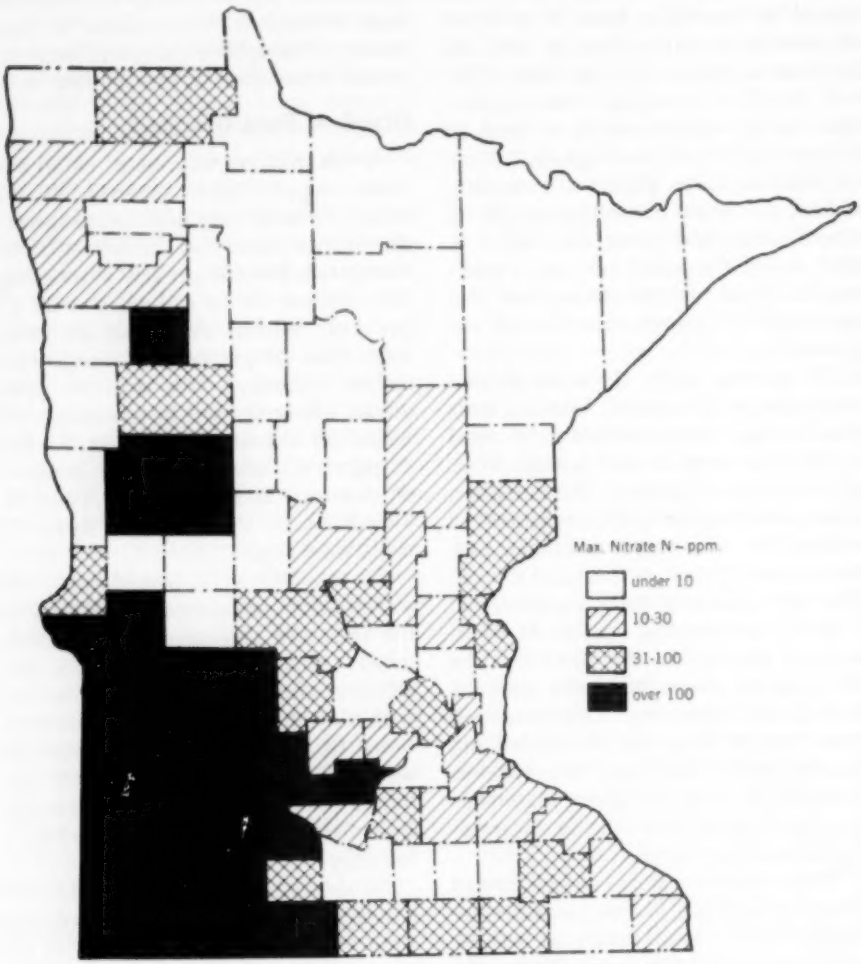


FIG. 2. Nitrate Nitrogen Concentrations in Well Water

lected from the sources of supply and from the distribution system in each instance. No significant change was noted in the nitrate nitrogen concentration during the first seven months of sampling.

Private supplies. Four of the wells involved in cases of methemoglobinemia were sampled biweekly beginning in February 1949. These wells included two which were later reconstructed. The remaining two were dug wells, one at Tyler (Lincoln County), and the other at Woodstock (Pipestone County), both of which were located satisfactorily. A fifth supply, a drilled well located ¼ mile west of the reconstructed well at Luverne, was also sampled, although it had not been involved in a methemoglobinemia case. This well was located adjacent to a barnyard. No significant changes were noted in the nitrate nitrogen concentration of these supplies, although the concentration appeared to decrease slightly. The two wells near Luverne were sampled at intervals after more than an hour of continuous pumping. No significant changes in chemical concentrations due to length of pumping were noted.

Laboratory results. During the period January 1, 1947, to August 1, 1949, the laboratory made nitrate determinations on 2,912 water samples. Approximately 800 were submitted specifically for nitrate determination; the remainder were collected primarily for some other reason. Of these samples, 440 (15 per cent) collected from wells in 54 counties, contained over 10 ppm. nitrate nitrogen. The highest concentration found in each county is charted in Fig. 2. The white areas indicate counties in which the highest nitrate nitrogen concentration of samples included in this study was less than 10 ppm. The blacked-out area, which predominates in the southwest corner, indicates the occurrence of nitrate nitrogen concentrations greater than 100 ppm. It will be recalled that the southwestern section is the area from which most of the methemoglobinemia cases have been reported.

Well Reconstruction

Two of the private supplies which had been sampled biweekly were reconstructed to conform to state standards in an attempt to determine the effects, if any, on the nitrate concentration. A properly located dug well of 30-ft. depth and a poorly located drilled well, 71 ft. deep, were chosen. Both of these supplies had been involved in methemoglobinemia cases. Sampling of the wells after reconstruction did not show a significant reduction in the nitrate concentration.

Summary

1. Since January 1947, 139 cases of methemoglobinemia, including 14 deaths, due to nitrate nitrogen in farm well water supplies, have been reported in Minnesota.

2. Dry- and evaporated-milk formulas which require large amounts of water as diluent are most dangerous; pasteurized cow's milk, undiluted and acidified, is the safest formula for infant feeding.

3. With one possible exception, no infants who were breast fed developed methemoglobinemia, a fact which suggests that breast feeding is advisable in the first two months of life, especially in rural areas.

4. Data are presented on water supplies suspected of being implicated in cases of infant methemoglobinemia in

Minnesota. In all but two of these cases, the nitrate nitrogen content of the water was in excess of 20 ppm. In the two exceptions mentioned, the clinical histories of the suspected cases were inconclusive.

5. Data are presented on the nitrate nitrogen content of wells in Minnesota.

6. Studies of rural school wells and similarly constructed nearby farm wells indicate that the nitrate content of the school well water was less than that of water from the farm wells.

7. In many of the situations where well water has been found to contain significant amounts of nitrate nitrogen, there has been a variation in concentration. Boiling of the water used in making the formula serves to concentrate the nitrate nitrogen in proportion to the amount of reduction of water volume. Consequently, although no cases of methemoglobinemia are known to have occurred in Minnesota from using water containing less than 30 ppm. of nitrate nitrogen, 10 ppm. has been established as the point above which the water should be viewed with suspicion because of the possibility of a dangerous level being reached at other seasons or after boiling.

Acknowledgment

This study was initiated with the guidance and assistance of the following committee, but any ideas or conclusions in this paper are not necessarily the opinions of the committee: Gaylord Anderson, M.D.; A. C. Caldwell; Hunter H. Comly, M.D.; Theodore A. Olson; H. A. Whittaker; and Viktor O. Wilson, M.D. John Stam, M.D., Worthington Clinic, acted as pediatric consultant in this study. The work was aided in part by a grant from the U.S. Children's Bureau.

References

1. Comly, H. H. Cyanosis in Infants Caused by Nitrates in Well Water. J. Am. Med. Assn., **129**:112 (Sept. 8, 1945).
2. Cornblath, M. & Hartmann, A. F. Methemoglobinemia in Young Infants. J. Pediat., **33**:421 (Oct. 1948).
3. Borts, I. H. Waterborne Diseases. Am. J. Pub. Health, **39**:974 (1949).
4. Robertson, H. E. & Riddell, W. A. Cyanosis of Infants Produced by High Nitrate Concentration in Rural Waters of Saskatchewan. Can. J. Pub. Health, **40**:72 (Feb. 1949).
5. Waring, F. H. Significance of Nitrates in Water Supplies. Jour. A.W.W.A., **41**:147 (Feb. 1949).
6. Weart, J. G. Effect of Nitrates in Rural Water Supplies on Infant Health. Ill. Med. Jour., **93**:131 (March 1948).

Water Well Redevelopment by Explosives

R. M. Ebaugh

A paper presented on Oct. 28, 1949, at the California Section Meeting, Sacramento, Calif., by R. M. Ebaugh, Constr. Supt., Southern California Water Co., Los Angeles.

MOST of the arid West depends upon wells for its water supply. A large influx of population and rapid industrial growth have in many areas imposed a tremendous draft upon the underground waters, and the basins are being depleted. If proper records have been kept, however, it will be noted that many wells lose productivity all out of proportion to the declining water tables. This statement obviously holds true of wells drawing upon aquifers which are not being depleted, and it is further verified by the comprehensive water level records of the Southern California Water Co., with over 150 water wells of various diameters having depths as great as 2,000 ft. Wells in which the drawdown, or difference between static and pumping water levels, increases out of proportion to other wells might be termed "sick," and there must be a reason for this loss of productivity.

The increase in drawdown, with the resultant decrease in production, should first be checked by making certain that the productive zones have not been buried by sand within the well. If "sanding off" is not the reason, then the cause must be due to other factors, such as fines in the formation which seal off the coarser layers; growths, incrustations or other deposits in the perforations or formation; or various combinations of these factors. As this increase in drawdown results in a loss of pump efficiency and in a greater pumping lift, with a resultant decrease in the output of needed water, it is uneconomical to permit such a condition to exist. When mining the water, it is best to do it efficiently.

In the belief that something could be done to restore the productivity of such wells and thus add to the total supply, various methods of redevelopment have been tried by the Southern California Water Company. These include backwashing, use of air lift, dry icing, acidizing and swabbing. Only swabbing has had beneficial results, and the records show that even these were very short-lived. Although the well might have been restored to its original productivity, it very rapidly sealed off and at the end of a few months was no better than before swabbing. Practically all of these methods require the removal of the pump and redevelopment work, and sometimes the installation of a larger test pump, its removal and then the installation of a permanent pump. Costs have occasionally exceeded $2,000.

The failure of all these methods led to a series of experiments using explosives. Although there is more to be learned, satisfaction is felt that a practical method has been developed which will go far toward solving one of the industry's worst problems.

A method of redeveloping water wells which has actually reduced pumping lift by 41 per cent, which has restored the efficiency of the turbine from 47 to 71 per cent and which has tripled production—an actual increase of from 500 to 1,500 gpm. in one well—might sound fantastic. Yet such results have been accomplished by the use of explosives.

The petroleum industry has pioneered the use of explosives in wells. Various types of explosives are used for the initial development of the wells and the redevelopment of producing wells by clearing the perforations. The most recent advance is the use of shaped charges to break up pieces of steel dropped to the bottom of the hole, to cut casings in two and to penetrate one or more thicknesses of casing and out into the formation.

A survey shows that explosives of various types have also been used in the redevelopment of more than 200 water wells. These explosives have ranged from No. 6 caps to 50-grain charges of pentaerythrite tetranitrate (PETN).* As far as can be learned, the use of explosives for this purpose (called "shooting a well") has been strictly a hit-or-miss proposition.

Earlier Experiments

Plain No. 6 electric detonating caps have been used in the majority of water wells shot, a number of caps being wired in series in a string and fired. Results were on the whole questionable, although one operator near Bakersfield, Calif., reported "beneficial" effects. No tests or drawdown curves were ever made, before or after, to determine the exact results. The operator looked at the stream of water and from this casual observation judged the amount of improvement, if any. Tests by the Southern California Water Co. showed no benefits.

Pentaerythrite tetranitrate, PETN for short, had been used successfully in eight known redevelopment projects at the time it was called to the company's attention.† It is a very high explosive which comes in a waterproof, fuselike container and may be obtained in charges of 30, 50 or 100 grains per foot. PETN is very simple to use. It can be purchased in 1,000-ft. lengths, which can be cut as desired to match the length of the perforated sections. Shooting is done by attaching a small weight to the bottom portion and lowering the prepared string into the well. A detonating device, attached to the uppermost portion, is fired through a combination supporting cable which is an electrical conductor. Because of its small diameter, the cable can be lowered into a well past the bowls of the turbine pump, if a ¾-in. clearance is available. The PETN is placed opposite the perforations and fired by a surface exciter.

Investigation showed that an oil field service company held the license rights for the use of PETN in redeveloping oil wells and was considered to be an authority on this subject. The service company engineers were most willing to try to adapt their method to water wells. In their belief, it was safe to use 30-grain PETN for the large-diameter thin casings used in California water wells. These casings consist of continuous telescoping 4-ft. sections with the inner and outer joints staggered. Buried jacks pull them to-

* Commonly known as "Primacord," a trade name of Ensign-Bickford Co., Simsbury, Conn. "Primacord" was used in the tests mentioned in this paper.

† The patent for the use of this material in oil and water well development is owned and controlled by Ford Alexander, Arcadia, Calif.

gether and force them down the hole as drilling advances. The casing may consist of two sections of pipe ranging from 14- to 8-gage and from 10 to 30 in. in diameter. The strength of this type of casing leaves much to be desired, and it was as a considered risk that string shooting was decided upon.

Under supervised tests, thirteen wells were shot using 30-grain PETN. Although increased water production resulted, two of the wells were slightly damaged. Subsequently other wells, not under these supervised tests, were seriously damaged, to such an extent that the license holder for this method considered withdrawing from the water well field. Some casings were cut at the fluid level, a phenomenon very familiar to the naval authorities. Another was split longitudinally, and still another was torn at regular intervals, suggestive of the pipe organ effect. In later experimental work, these effects were all duplicated.

The results obtained by the use of explosives were most promising, but they showed the necessity of making a study of the behavior of explosives to determine if their power could be safely harnessed for the benefit of the water industry. Numerous letters of inquiry were sent to various authorities in an effort to learn something of the laws governing explosives and to find a method of computing the effects of particular explosives on casings of various diameters and thicknesses. No satisfactory replies were received, however. It was therefore decided to call upon two of the outstanding consulting explosive experts in the nation, one of whom held the patent rights to the vibratory-explosive method described below. It was under their supervision and guidance that the company's tests on high explosives were made. The remainder of this paper will be a summary of this study, the experiments conducted and the formulation of a safe method of redeveloping water wells by explosives.

Behavior of Explosives

Explosives are a relatively unstable combination of organic and inorganic compounds. Meyer (1) states: "In general, an explosive is any material which will undergo a rapid change accompanied by a large increase in volume. This increase in volume accounts for the pressure, and the heat liberated still further increases the volume of gases formed, usually in a ratio of more than 1,000 to 1. The force produced by the volume increase, plus the explosion wave resulting from the rapid compression of the surrounding medium immediately followed by a rarefaction, accounts for many of the practical phenomena."

There are two main types of explosives: the propellants, or low explosives, and the high explosives. The main characteristic of low explosives is that they burn just as a piece of wood burns, although much more rapidly; during their rapid combustion they generate temperatures up to 3,000°C. and likewise liberate large quantities of gas. Davis (2) defines propellants or low explosives as "combustible materials, containing within themselves all oxygen needful for their combustion, which burn but do not explode, and function by producing gas which produces an explosion. Examples are: black powder and smokeless powder."

A high explosive, on the other hand, is characterized by an initiating shock wave, which, traveling with a speed on the order of 20,000 fps., passes through the primary explosive, upsetting its chemical equilibrium with a resulting detonation. According to Meyer (1), the "high velocity of explosion, as com-

pared with a low explosive, produces a shattering effect which is qualitatively different, and makes [high explosives] unsuitable for driving a projectile. The effect is sometimes compared to a blow as opposed to a push."

A chain or "sympathetic" reaction will occur if several explosives are spaced close together. When the first is fired, the rest will go off one after another as the shock wave from the initiating explosive detonates its adjacent

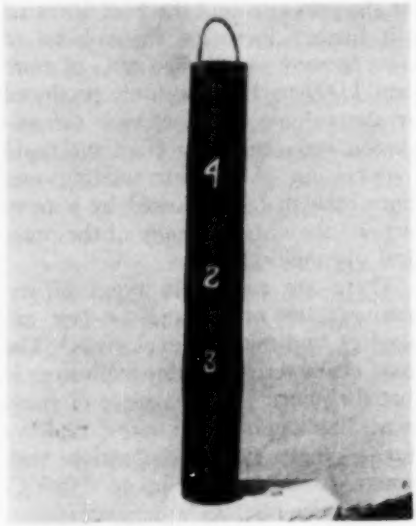


FIG. 1. Effect on 14-Gage Casing

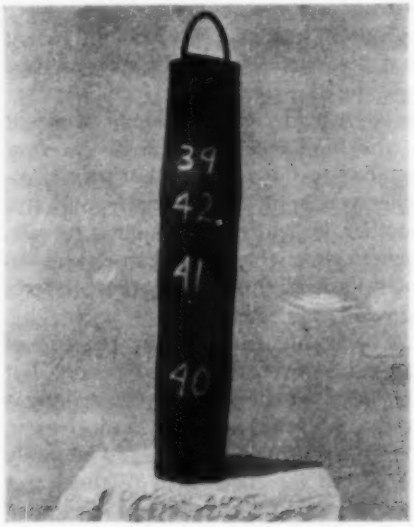


FIG. 2. Effect on 10-Gage Casing

neighbor and so on down the string. For this reason, powder magazines are built a considerable distance apart. It is another well established fact that, when two adjacent explosives are set off simultaneously, their shock waves reinforce each other where they meet.

The effect of the large quantities of gas generated by explosives in underwater explosions has been intensely studied by Cole (3), using photography and fast recording gages. As the gas bubble formed underwater expands, it forces the water to move away, producing what is termed an "afterflow" or an enlargement of the bubble beyond its normal capacity. The bubble then contracts, drawing the water in after it until the bubble is compressed to the maximum degree. The cycle thereupon repeats itself, a process which occurs about ten times, on the average. The expansion-contraction cycle possesses approximately 20 per cent of the force and as high as 40 per cent of the energy of the initial explosion. When confined within a casing, this energy and force is naturally exerted against the casing.

In all, 52 experimental shots, not counting 18 wells shot, were made to determine the effect upon casings of [1] high explosives, including PETN; [2] detonators; and [3] the vibratory explosive method. These experiments were conducted in an abandoned water well which was cemented at 100 ft. and filled with water. It was possible to

take selected samples of various casings, mount any type of explosive at any position desired in the tube, either centered or off center, and explode it at varying depths up to 100 ft.

Effect on Steel Pipes

Explosives are generally thought of in terms of uncontrolled damage to structures. As a matter of fact, high explosives, when properly used, can yield controlled effects which are reproducible. Considerable experimentation was carried out to establish the upper limit of the amount of explosives which can be used before serious damage is done to the casings. Having determined this limit, it is obviously possible to decrease the power of the explosive to stay within safe limits for water well redeveloping at all times. In order to establish this maximum limit, various amounts of high explosives were detonated in test sections of thin-wall casings, perforated and unperforated. As the amount of the explosive was increased in a casing of a given diameter and thickness, immersed in water, the tube began to bulge slightly, and finally, under increasing charges, was ruptured when its elastic limit had been exceeded.

FIG. 3. Effect of Detonator Placed Against Casing

Figure 1 depicts experimental shots No. 2–4 in a section of 8-in. (od.) 14-gage casing. Shot No. 2 consisted of a small amount of high explosive under 30 in. of water. The diameter of the casing was increased approximately $\frac{3}{16}$ in. For Shots No. 3 and 4, equal quantities of high explosive were used, the amount in each test being larger than for Shot No. 2. Shot No. 3, submerged 30 in., increased the casing diameter $\frac{1}{2}$ in., while Shot No. 4, submerged 90 ft., produced an increase in diameter of approximately $\frac{7}{16}$ in. Figure 2 shows a series of experi-

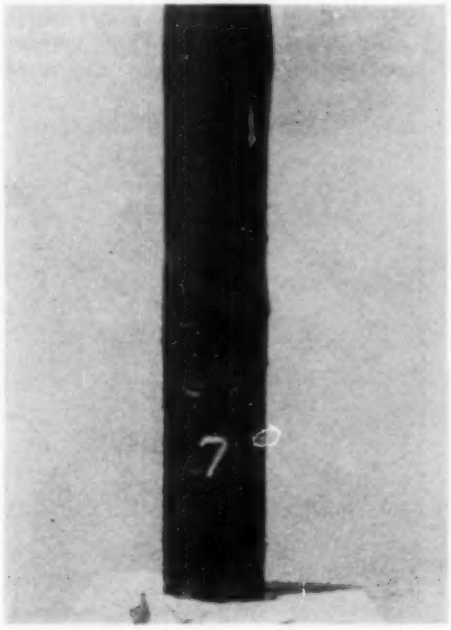


FIG. 4. Detonator Placed Against Casing Perforation

mental shots, No. 39–42, made in a section of 6-in. (id.) 10-gage casing. As the amount of the charge was increased, the diameter of the pipe increased from $\frac{1}{8}$ to 1 in. The two tubes used were of different types of steel. These seven shots demonstrate that the pressure exerted against the casings was above the yield and below the rupture point of the tubes. It may be seen how accurately an explosive can be controlled.

The bursting strength of various pipes can be computed by means of Barlow's formula. From the data collected during the tests, and as a result of earlier work by Franklin E. Roach, it was found that a simple formula represents the pressure developed by an explosive confined in a tube with water both inside and outside of the tube. Utilizing these two formulas, it is always possible to compute the safe amount of explosive for redeveloping wells.

The casing of the abandoned well was cut at the fluid level three times as a result of large charges of high explosives, once unintentionally and twice deliberately. In an attempt to cause a section of large-diameter double 8-gage pipe to bulge, a very heavy charge was used. The shock wave knocked out the cement plug and cut the casing at the water level, so that the sample could not be recovered. The well casing having been cut accidentally, the same test was repeated twice later. In each experiment, the casing was cut around its circumference at the fluid level, a phenomenon which occurs only when large charges of high explosives, or those possessing great energy, are used. This effect can also be controlled in water wells.

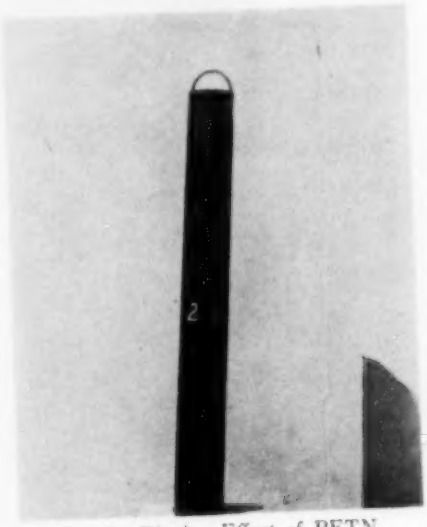


FIG. 5. Ripping Effect of PETN

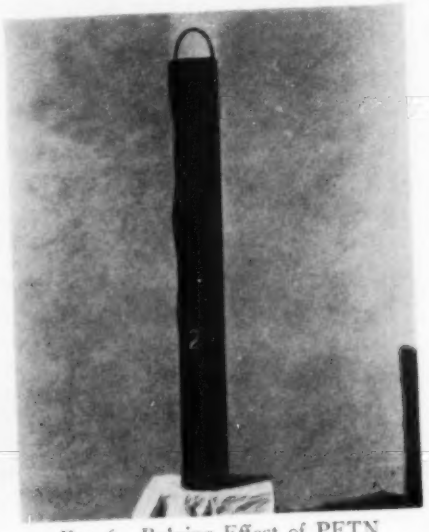


FIG. 6. Bulging Effect of PETN

It was interesting to observe the difference in results with perforated and unperforated sections of casing. The bulging action could be obtained quite readily by using the proper amount of explosives in the unperforated sections, but the effects were not as noticeable in the perforated ones. This difference held true for various

types of explosives. Either the shock wave was vented through the perforations, or else they reduced the effect of the shock wave upon the casing. Some specimens of welded and standard-weight butt-weld pipe failed to bear up to their specified bursting pressures, apparently because of inadequate production testing. The application of the bulging principle in setting liners and plugs at any desired depth in oil wells is patented.

Detonators

Single No. 6 or No. 8 detonators produced no effect upon either perforated or unperforated sections of pipe when mounted either in the center or adjacent to the casings. Figure 3 (Shot No. 22) shows a small protuberance on the external surface of an 8-in. (id.) 14-gage casing produced by wiring the high-explosive end of a No. 6 cap directly in contact with the casing. The shot resulted in a hemispherical protuberance with a small tear at its base. The tear did not exceed $\frac{1}{8}$ in., which is as small as any perforations made by the Mills or Moss methods. Figure 4 (Shot No. 7) shows the effect upon a perforation when a No. 6 vibratory cap was taped in place within the perforation. The lower portion of the perforation was bent inward, the upper portion outward. The opening was increased from $\frac{1}{4}$ to $\frac{3}{8}$ in. These results represent the worst possible situations that can arise in the firing of a well when using detonators, and the likelihood of such occurrences is very slight.

A series of tests was conducted to determine how close to each other detonators could be placed before they fired sympathetically. The safe distance depends on the amount of the explosive and its intensity.

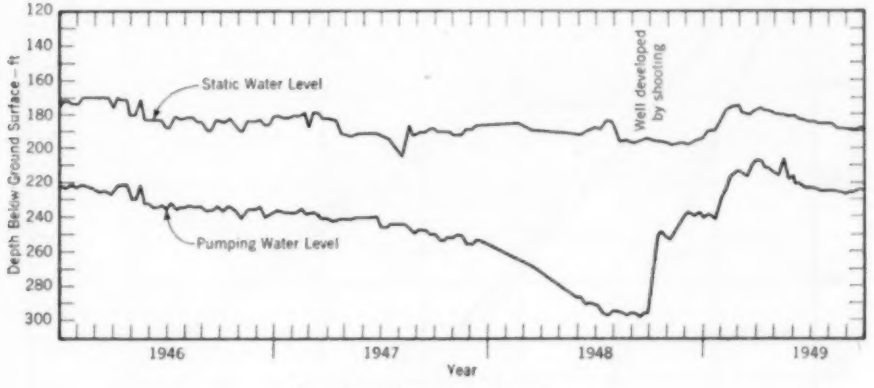


FIG. 7. Water Level Record

PETN

In a series of tests using 30- and 50-grain PETN in a string, the deleterious effects on well casings previously mentioned were reproduced. As shown in Fig. 5 (Shot No. 28), the 8-in. (od.) 14-gage sample was split lengthwise by the tremendous energy of PETN. The use of 30-grain PETN in the same type of casing caused it to bulge in three places, 27$\frac{1}{2}$ in. apart at the point of maximum bulge (Fig. 6). No explanation for this phenomenon has been found, but it was noticed that the effect was most pronounced in the unper-

forated sections, being very slight in the lower or perforated sections. Computations show that the equivalent mechanical energy of a string of 30-grain PETN is about 300,000 hp.

In comparing the application of PETN in oil and water wells, it must be remembered that the latter have a much lighter casing and the submergence of the firing is very much less than in an oil well. It is thus more readily understandable why the water well casing is subjected to damage. The results of these tests confirmed the intention of the license holder to withdraw from the water well redevelopment field.

Vibratory-Explosive Method

Experiments with PETN indicated that beneficial results of considerable magnitude could be obtained by the use of explosives. A 50-ft. length of 30-grain PETN will detonate in about $\frac{1}{400}$ second, and in that time approximately 3½ oz. of PETN is used. If that amount of explosive is detonated as a sphere, it will explode in about $\frac{1}{20,000}$ second at most, doing intense local damage but not damaging the casing from top to bottom, as has actually happened in water wells and in these tests. The experiments showed that 2 ft. of 30-grain PETN (approximately ½ oz.), shaped as a sphere and fired in

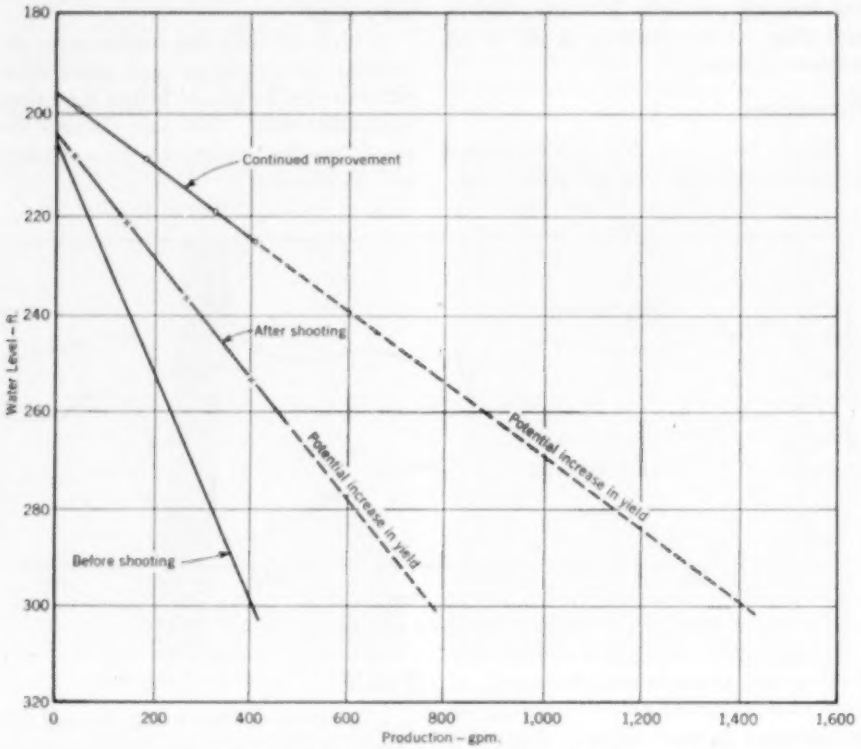


FIG. 8. Decrease in Drawdown in Old Well

8-in. (od.) 12-gage casing, produced no bulge when fired in the center of the tube. It did, however, give a very effective "slap" to the casing in its immediate vicinity. This amount of PETN per foot was twice that which, suspended as a string, ripped the casing. A larger area of perforated casing could be "slapped" properly if the charges were closely spaced, but, when the charges were fired simultaneously, the casing would in all probability be damaged by the reinforcement of the shock waves. Slowing down the rate of the explosion would avoid the damage, but, by their very nature, explosives detonate very rapidly or not at all.

The dust can be removed from a window screen by raising it a few feet from the ground and letting it crash, but the frame may not withstand the blow. If the screen is raised only a few inches, however, and repeatedly tapped against the ground, or actually vibrated, a much better job of cleaning is done at no risk. Similarly, in a well casing, a series of closely spaced, small charges fired at accurately timed intervals would solve the problem of excessive horsepower, and, paradoxically, a larger amount of explosive per shot could then be safely used, if desired. Obviously, more beneficial results can be obtained by a series of smaller blows continued over a longer period of time, producing a vibratory effect. It appeared possible to extend the beneficial effect of the vibratory explosive over a period 100 times as long as when using PETN. In fact a method of increasing this period as much as 5,000 times was successfully worked out.

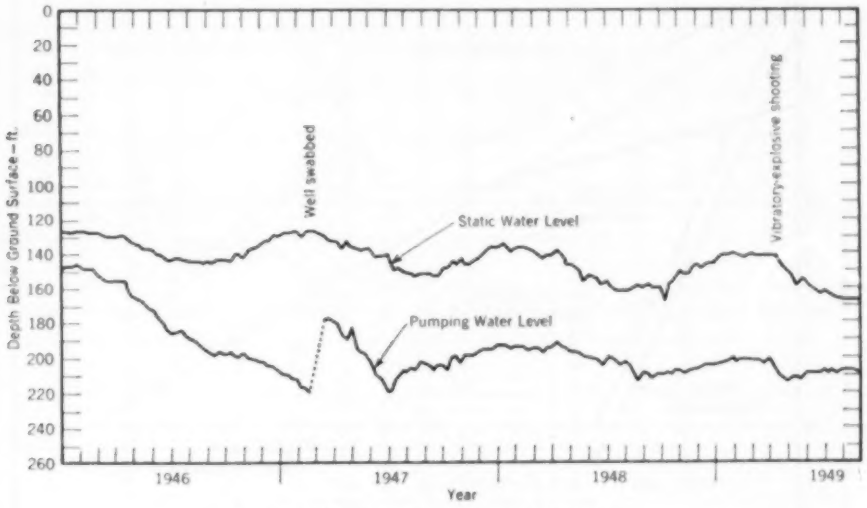


FIG. 9. Effect of Swabbing and Shooting

The heat of explosion for 1 g. of PETN is 1,440 cal. One foot of 30-grain PETN represents approximately 2 g., or 2,880 cal. Explosives can be purchased commercially with as low as one-ninth the strength (320 cal. per gram) of 1 ft. of PETN. Thus, if the period of the explosion is extended 5,000 times and its power decreased to one-ninth, the energy of the vibratory-

explosive method can be reduced to $\frac{1}{45,000}$ that of PETN, if desired. In this fact lies the safety of the method.

The final solution of the problem takes advantage of the few laws of explosives outlined earlier and utilizes the knowledge gained in the series of tests. After prior computation, a series of selected explosives are spaced on various leads and fired at specified intervals of time throughout the length of bubble expands and contracts ten times, on the average, as a result of each single explosion, so that the water is forced out through the perforations and back into the hole ten times for each shot. Upon completion of this cycle, the second series of shots is fired, and so on. The time can be varied by means of a special firing mechanism. It is thus possible to use safe charges of sufficient force to dislodge or break up

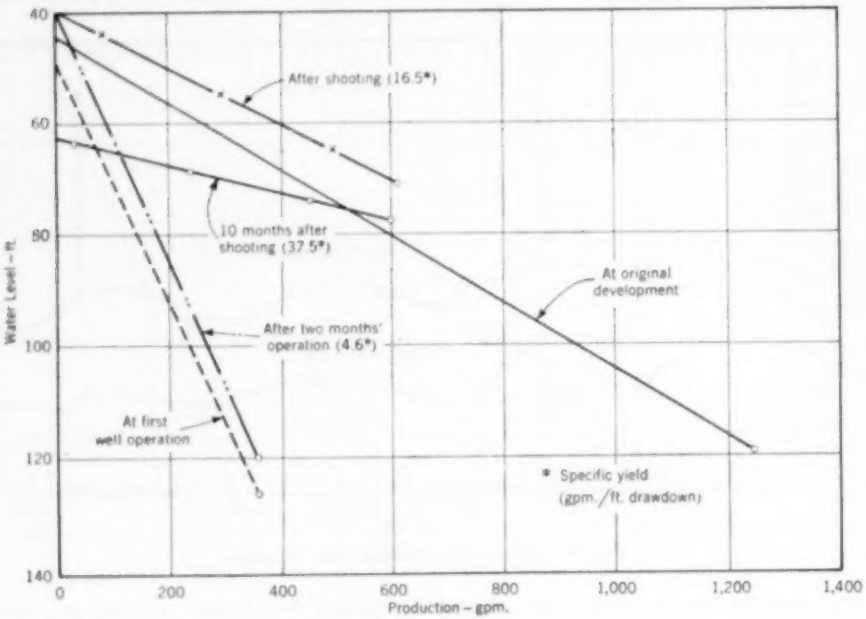


FIG. 10. Decrease in Drawdown in New Well

the perforated area. The explosives produce a continuing series of shock waves safe to use in various casings, yet powerful enough to shatter and dislodge obstructions in the perforations or in the interstices of the surrounding formations. Cole's study and analysis of the bubble cycle solved the problem of the time spacing between series of shots and the removal of the dislodged material. It will be recalled that the any incrustations or other material and wash them free by means of the bubble cycle. This method is patented for water and oil well redevelopment.*

Results Produced

The proof of any process is in the results produced. Figure 7 shows the pumping record of the Ballona well.

* Patent held by Norman A. MacLeod, Altadena, Calif.

It will be noticed that the drawdown had been increasing for an appreciable period of time. In September 1948 the well was shot, with a resultant decrease in drawdown of 50 ft. The water level records show that the beneficial effects have been long lasting. The drawdown curves for this well before (August 24, 1948) and after (October 8, 1948) shooting, and approximately one year later (September 14, 1949), are given in Fig. 8. A great potential increase in yield is indicated, assuming the installation of a new pump and the maintenance of the same pumping level that prevailed before shooting. It is realized that this condition may not always hold true, but in another well, not in this series of tests, the yield actually did increase to its full potential. A pump of 1,500-gpm. capacity had originally been installed in this well. As production declined, the discharge valve was pinched back until the well was pumping at a rate of 500 gpm. with a 360-ft. pumping level. Upon completion of the shooting, the well produced 1,500 gpm. with a 320-ft. pumping level.

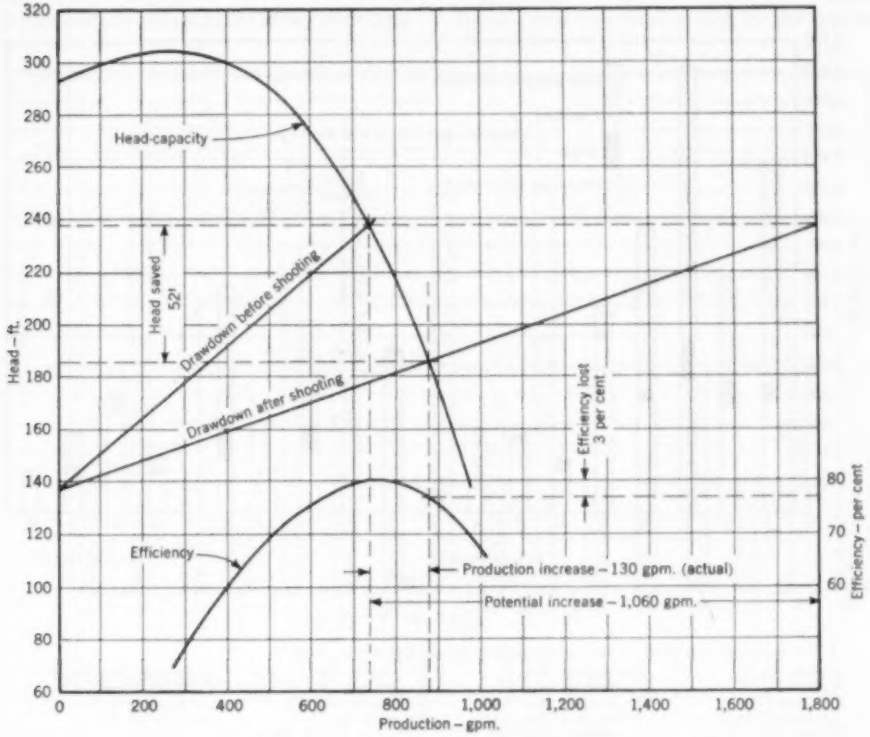


FIG. 11. Effect on Pump Operation

Figure 9 shows the results obtained at Truro No. 2 well by swabbing in February 1947. The yield rose from 400 to 830 gpm., but the benefits were short-lived. The same well was redeveloped by the vibratory method on April 9, 1949, before full information

had been obtained on the length of the bubble cycle. It was believed that no benefits were obtained. In fact, the pumping level actually dropped 10 ft. As the graph shows, however, the pumping level has remained stationary, while the static level has been steadily dropping. In other words, the drawdown curve has been assuming a flatter angle, indicative of a greater yield per

turbine pump was installed, fine-grained formations had sealed off the productive areas. The chart shows plainly the beneficial results obtained by shooting this brand-new well.

Figure 11 shows the results of shooting a water well, superimposed upon the normal pump curve. The increase in production is always limited by the characteristics of the pump curve. In

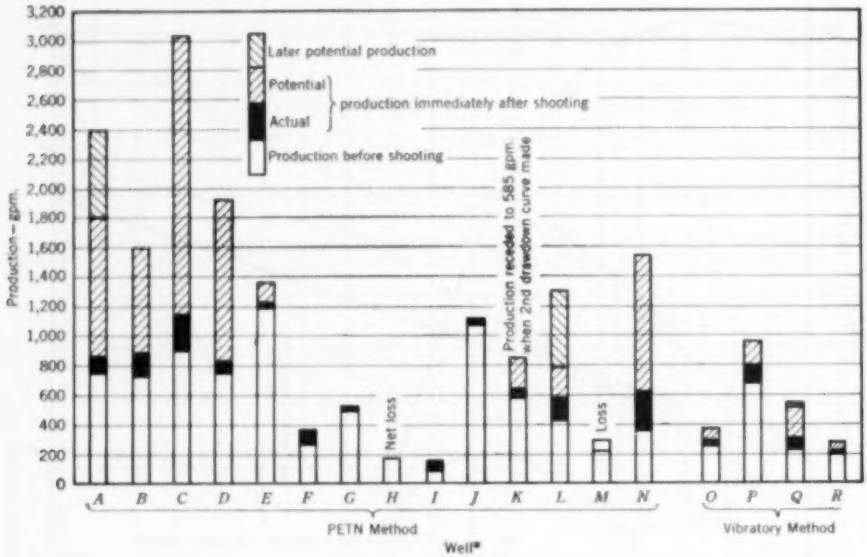


FIG. 12. Effect on Production

* The wells corresponding to the letter symbols are as follows:

A—Yukon No. 1	*F*—Sentney No. 5	*K*—Towne No. 2	*O*—Normandie No. 2
B—Yukon No. 2	*G*—Sentney No. 7	*L*—Ballona No. 2	*P*—Adelaide No. 1
C—Chadron No. 1	*H*—Sentney No. 8	*M*—Normandie No. 3	*Q*—Hampshire No. 12
D—Rosecrans No. 2	*I*—Sentney No. 10	*N*—Vine No. 2	*R*—McVine No. 1
E—Watson No. 1	*J*—Sentney No. 12		

area of perforations for the well. Incidentally, reference is generally made to the yield of a well per foot of drawdown. It would be much better to consider the yield based upon the unit area of the perforations. Figure 10 shows the drawdown curves for the Vine No. 2 well. During the three-month interval between the time of original development and the time the

the particular well involved, it will be noted that the pump efficiency actually dropped from 80 to 77 per cent. It was believed, however, that because of the lowering water table, it was best to keep the production on the right-hand side of the efficiency curve. Thus, as the water table dropped, the efficiency of the unit would be increased without changing the pump. A gain of 130

gpm. was obtained without installing a pump of greater capacity, providing an equivalent of 25,000 cu.ft. additional per day, or 1 acre-ft. of water in 1¾ days. An acre-foot of water costs approximately $20 in Southern California.

Figure 12 shows the effect on production of all eighteen wells redeveloped by explosives to date. "Potential production immediately after shooting" assumes the same pumping level as before shooting. "Later potential production" likewise assumes the same level but is based on a drawdown curve made some time after shooting.

The first four wells shot produce water from coarse gravels and sands of late Upper Pleistocene marine deposits. The water from all four wells was high in hydrogen sulfide. When the pump was turned on after shooting, the water was literally as black as ink, because of its iron sulfide content. The results for these wells were most gratifying.

Watson No. 1 produces water from what were originally Pleistocene terrace deposits, while the Sentney wells produce from Recent and Upper Pleistocene lagoonal-ooze deposits. These oozes are actually fluid and hence only slight benefits resulted. Had these been the first wells in the series of experiments, the tests would have been discontinued.

Towne No. 2 and Ballona No. 2 are in Upper Pleistocene marine deposits, as are Vine No. 2 and Adelaide No. 1. Ballona No. 2 and Adelaide No. 1 were high in hydrogen sulfide and aquatic growths. These wells produced from varying formations and were sealed off by different materials.

The benefits shown for the wells shot by PETN, with the exception of

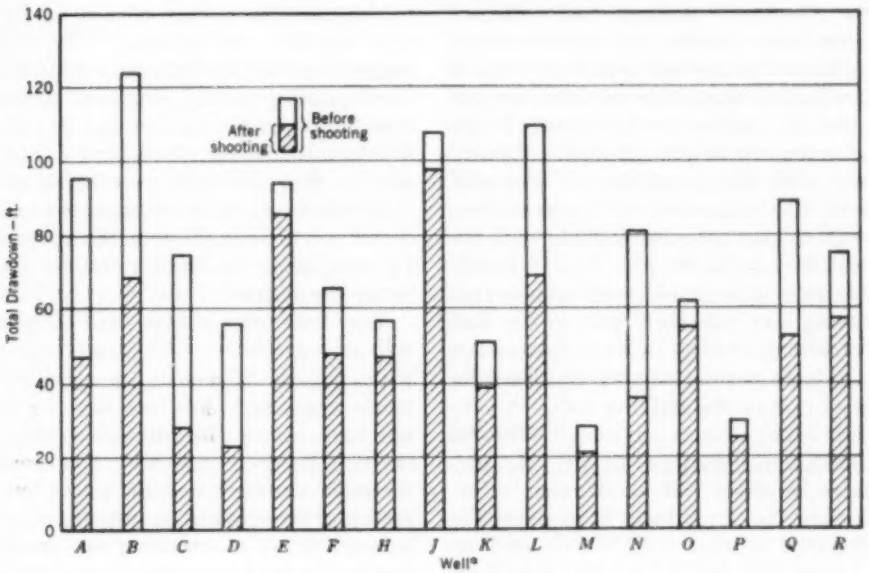


FIG. 13. Effect on Drawdown

* For names of wells, see p. 182.

the Sentney group which produces from lagoonal oozes, apparently tower above those resulting from the vibratory-explosive method. It must be noted, however, that the PETN wells were the ones with the greatest drawdown. Furthermore, the vibratory-explosive method was used not only to give a direct comparison with PETN, but also to determine its safety and its effect upon depleted aquifers.

Hampshire No. 12 was so old that its lowermost portion had collapsed nine years before the present tests. A smaller pump had been installed and production was obtained from the uppermost shallow perforations. If the vibratory-explosive method harmed any well, this would be it. The well was shot according to computations, with no damage resulting and with the benefits shown in Fig. 12. Adelaide likewise was an old well with a thin casing. It is located close to the Ballona well, is high in hydrogen sulfide and has a perforated area much smaller than that of the Ballona well. A very light series of shots was used. Whereas Ballona was damaged by PETN, Adelaide benefited with no damage. Normandie No. 2 produces from a partially depleted aquifer. PETN caused its counterpart, No. 3, to lose production, but the vibratory-explosive method resulted in a substantial benefit to No. 2. McVine produces from Recent terrestrial deposits in a greatly depleted aquifer. The beneficial results in the latter two wells were a distinct surprise. Thus, based upon direct comparison, the vibratory-explosive method proved safer and better than PETN.

Figure 13 shows the decrease in drawdown in each well shot, without changing pumps. This graph, together with Fig. 12, clearly demonstrates that it would have been practical to install pumps of greater capacity and take full advantage of the benefits obtained with the explosives.

Observations

It must be realized that the Los Angeles Basin is very young geologically, most aquifers ranging in age from Pleistocene to Recent. The strata are on the whole unconsolidated. They vary from large boulders to fine silts, and, along the detrital cones adjacent to the mountains, they consist of Recent boulders and gravels. The clay logged by many drillers is in actuality decomposed granite. Adjacent to the ocean, some of the aquifers are actually fine lagoonal oozes, which have a tendency to flow and have no compaction. In the few wells shot to date, the evidence would indicate that the greater the compaction of the formations, the better the results.

The time required to redevelop a well is very short. If a round object with a ¾-in. diameter can pass the bowls, the pump does not have to be removed. It can be raised, the series of shots lowered on a cable and fired, the cable removed, and the pump lowered and reconnected to the discharge piping. After reconnecting the pump, results can be determined immediately. The well should be surged after firing until maximum benefits have been obtained, a process which generally requires about one hour. Most of the wells have been cleaned up within ten minutes.

The amount of material removed is surprisingly small. Slight quantities of silts and fine sands finally yield to medium-grained sand. Minute particles of tuberculation and larger portions of mill scale have been observed in all wells shot. Those wells with a great deal of hydrogen sulfide yield

black water high in iron sulfide for a short period. Where present, aquatic growths, both dead and alive, appeared in sheetlike form in large quantities, as well as in minute fragments.

One interesting difference between the PETN and the vibratory-explosive method is the greater amount of fine material removed by the latter. The vibratory method takes full advantage of the bubble cycle to wash the perforations thoroughly.

Conclusions

1. Water wells can be redeveloped safely by explosives.

2. Explosives, if properly used, are the least expensive, require the shortest shutdown time and produce the least disturbance in the pumping unit, of any method to date.

3. If indiscriminately used, explosives are definitely harmful to the property and can ruin a well.

4. The vibratory-explosive (patented) process is the best method of redevelopment utilized to date. It is safe, because explosives follow definite laws, and formulas have been developed to calculate explosive force which can be applied to the function desired. The method is effective—small charges, accurately timed, clean the casing and surrounding formations. It is convenient—small, multiple charges can be detonated at any position inside the casing, thus leaving the pump undisturbed. Finally, the method is thorough, complete cleaning being produced by sustained vibration. By combining small charges, accurately spaced and carefully timed to utilize the ten washings of the bubble action and the secondary effect of colliding shock waves, the equivalent energy of high explosives can be made useful.

Acknowledgment

The author is grateful to C. P. Harnish, Pres., Southern California Water Co., for his wholehearted support and for permitting the extensive experimentation required for the preparation of this paper; to Norman A. MacLeod, explosives consultant, originator of the vibratory-explosive method and consultant in ordnance to the U.S. Navy; and to his associate Franklin E. Roach, research physicist for the U.S. Navy, under whose supervision and guidance much of the experimental work was performed.

References

1. Meyer, Martin. *The Science of Explosives.* Thomas Y. Crowell Co., New York (1943).
2. Davis, Tenney L. *The Chemistry of Powder and Explosives.* John Wiley & Sons, Inc., New York (1943).
3. Cole, Robert H. *Underwater Explosions.* Princeton University Press, Princeton, N J. (1948).

Infiltration Gallery at Ontonagon

By George W. Francis

A paper presented on Sept. 29, 1949, at the Michigan Section Meeting, Traverse City, Mich., by George W. Francis, Cons. Engr. & Mgr., The Francis Eng. Co., Saginaw, Mich.

INFILTRATION galleries roughly fall into two categories—those built in order to intercept the flow of underground water moving in a fixed direction; and those into which a flow can be induced by virtue of their location, such as proximity to the shore of a body of water. Of course, both types consist of some form of perforated tunnel or conduit into which the water can percolate and through which it may be conducted into a central receiving reservoir. The infiltration gallery at Ontonagon, Mich., is of the latter type and receives water both from aquifers that underlie the area away from the lake shore and from deposits that extend under Lake Superior.

The village of Ontonagon is located on the shore of Lake Superior close to the southwestern edge of Keweenaw Peninsula and at the mouth of the Ontonagon River. This river drains a rather large area which has a clay topsoil and consequently carries a heavy suspended load of clay, making it unfit for use as a water supply without filtration. The river also receives some pollution from the village itself and, in general, the condition of the stream varies in accordance with the winds, which either pile up or draw out the river flow. At one time the village secured its water from Lake Superior but ran into intake difficulties as well as the effect of river pollution, causing that source to be abandoned.

Because of the difficulty of obtaining water from the lake, Ontonagon many years ago sank what amounted to a deep well or cistern on an island in the river opposite the center of the village. A supply was obtained from this source by allowing the water to percolate through the sand of the island, but the water became unusable and a well was drilled into rock which ultimately yielded a highly mineralized supply. It might be worth noting that in some portions of the village it is necessary to penetrate a clay bed of only 15–20 ft. to secure a hard, mineralized and gaseous water. It suffices to say that, until the new supply was made available, Ontonagon had a water which was bad enough in taste, color and odor to give unanimous support to the undertaking of any project for an adequate and proper supply.

It appeared that Ontonagon could not use the well supply normally available to most Michigan villages. Furthermore, in spite of the fact that the village is on the shores of one of the finest water supplies in the country, the cost of constructing and maintaining an intake and crib in Lake Superior was considered to be beyond the village pocketbook. For these reasons, it was decided to investigate the possibility

of constructing an infiltration gallery along the lake shore, which was free of pollution and any material amount of habitation.

Gallery Design

A considerable number of test holes were drilled along the shore, and in one relatively small area a gravel deposit was encountered where it was thought to be worth taking a chance on the construction of an infiltration gallery. A plant, consisting of a circular concrete reservoir, 20 ft. in diameter, with a conical bottom, was designed and constructed about 75 ft. from the lake shore to avoid wave and ice action. The bottom of the reservoir is about 25 ft. below ground elevation, with a ceiling about 4 ft. below the immediate ground elevation, on which is mounted an octagonal superstructure. From this reservoir, two 18-in. perforated vitrified-clay pipelines extend north toward the lake. One of them turns and parallels the lake to the east, while the other turns to the west. The original design called for a little more than 100 ft. of perforated tile to be covered and surrounded with specially designed filter media of various graded sizes.

A section of perforated pipe is shown being laid in Fig. 1, while Fig. 2 shows the pipe covered by the filter media. The octagonal pumphouse above the reservoir can be seen in Fig. 3.

It was intended to construct first that portion of the gallery described above and, after a trial period, to proceed with as much more as might be necessary in either or both directions paralleling the lake.

FIG. 1. Laying Perforated Pipe

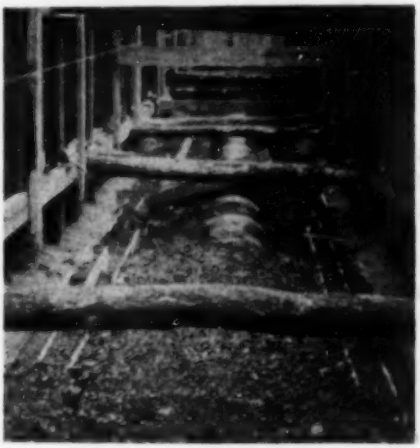


FIG. 2. Pipe Surrounded by Filter Media

Herman Gundlach, Inc., of Houghton, Mich., received the contract and the Thornton Construction Co., also of Houghton, was approved as the subcontractor to put in the gallery. The general contract was negotiated on a lump-sum basis, exclusive of the plumbing, heating and mechanical work, for which a cost-plus arrangement was made.

As the job did not get under way until late summer, construction was hampered by the stormy fall weather. On

several occasions the contractor lost sections of his work, but fortunately none of the gallery media. The original contract was completed on December 11. Incidentally, it was found that after the ice cover had formed on the lake, the severity of the weather no longer impeded construction.

Extension of Gallery

In the first test, the gallery gave a yield of 150 gpm., or about 2 gpm. per foot of gallery, assuming that substantially all of the water came from the pipe sections paralleling the lake shore. It was then decided to extend the gallery an additional 70 ft. to the east, which increased the yield to 350 gpm. A second extension of 80 ft. further increased the yield to 450 gpm. at a conservatively safe drawdown. As the total length of the gallery paralleling the lake was 236 ft., the ratio of 2 gpm. per foot of gallery was roughly maintained.

The reservoir alone has a capacity of 23,600 gal. between the static water level and the level at maximum drawdown, which is 10 ft. The amount of combined storage in the reservoir and the gallery depends on the time and the pumping period. Approximately 1.2 mil.gal. has been pumped over a 48-hour period, which should be enough for four days of maximum use. At the end of the single pumping period mentioned, the water was still being removed from the gallery at the rate of 450 gpm.

On May 5, 1949, a fire broke out in the village. After three hours of continuous pumping at the rate of 565 gpm., the reservoir drawdown was only 3½ ft.

Some standby pumping equipment remains to be placed in the station, but the final cost of the project is now estimated at close to $90,000.

One of the principal factors in the success of the project was the complete cooperation which the village council gave the consulting engineer and the contractor.

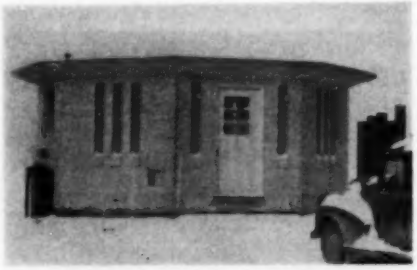


FIG. 3. Pumphouse Above Reservoir

The greatest worry during construction was the fact that underneath the clay bed which supports the infiltration gallery lies the aquifer of bad water previously mentioned. This water contains 5.2 ppm. iron and 190 ppm. hardness, compared with 0.24 and 60 ppm., respectively, in the supply which will now serve the village. All possible precautionary measures have been taken to avoid a breakthrough, and there is every reason to believe that none will occur.

Aboveground Pipeline Sections of Mokelumne Aqueduct

By James W. Trahern

A paper presented on Oct. 28, 1949, at the California Section Meeting, Sacramento, Calif., by James W. Trahern, Supervising Civ. Engr., East Bay Munic. Utility Dist., Oakland, Calif.

THE Mokelumne Aqueduct is a 94-mile-long transmission line, conveying water from the main source of supply of the East Bay Municipal Utility Dist. to the heart of the area served by the district. The aqueduct consists of approximately 9 miles of concrete-lined tunnels, 3½ miles of cast-in-place concrete pipe and 81 miles of parallel twin lines, constructed of steel and of reinforced concrete pipe. The capacity of the aqueduct, served by two pumping plants, is now approximately 160 mgd. but, with additional pumping facilities planned for future construction, will ultimately be 200 mgd. The aqueduct is exposed at steady flow to a hydrostatic head of 0–500 ft.

Construction of a portion of the aqueduct, including the tunnels, the cast-in-place concrete pipe and one of the twin pipelines, was completed in 1928. The second of the twin pipelines was completed in 1949. One of the existing pumping plants was constructed in 1928 and the other in 1945. The construction program for these facilities was timed to meet the requirements for water brought about by a constantly increasing population in the area served.

The tunnels and cast-in-place concrete pipe of the aqueduct consist of relatively large sections and were designed for the planned ultimate capacity of the aqueduct. The long twin pipelines, composed of smaller sections, were each designed to carry a portion of the ultimate capacity of the aqueduct. This arrangement of component parts was found to be the most economical. It should be noted that, where the twin lines cross three rivers, the ultimate capacity was provided for by the installation of twin pipes in the first line built.

The older line, ranging in diameter from 54 to 66 in., was constructed of steel pipe sections containing two welded longitudinal seams. The circumferential joints of the line are riveted. The diameter of the newer line varies from 54 to 68 in. A portion of the line, more than 14½ miles long, is of reinforced concrete cylinder pipe and the other portion, 66½ miles long, consists of steel pipe sections containing two welded longitudinal seams. The circumferential joints of the concrete portion are "lock joints," and those of the steel portion are of the welded bell-and-spigot type. The older line is protected by a bituminous coating inside and outside. In addition, buried pipe is wrapped with asphalt-impregnated felt, while aboveground pipe is coated outside with aluminum paint. The steel portion of

the newer line is protected by cement-mortar lining inside; cement-mortar coating outside, where buried; and aluminum paint outside, where aboveground.

Aboveground Sections

For the most part, the twin pipelines are buried in the ground. Over a 10½-mile stretch in the peat lands of the San Joaquin River delta, however, the lines are aboveground. In this region the ground water is near the surface and the topsoil is deep peat. Peat soil is unsatisfactory foundation material for supporting large pipelines, and, in addition, does not provide backfill material of sufficient density over the empty pipe to prevent it from floating. As peat soil is flammable, any line located in it would be subject to serious fire hazard. Preliminary estimates indicated clearly that aboveground lines in this locality would be far less expensive than properly designed buried lines. Elsewhere the reverse is true. It is interesting to note that, for the newer line, the average cost per linear foot of buried line was $43, far less than the average of $69 per linear foot for the aboveground line.

FIG. 1. Aboveground Pipelines (New Line at Right)

The general design of the aboveground sections was largely similar for the two lines. Both are constructed of steel pipe, provided with expansion

joints and anchored between them, as well as at changes in line and grade. Both pipes are supported on pile foundations. They are equipped with air and vacuum valves, fire hose connections, blowoffs and automatic wasteways. The lines are generally located from 3 to 6½ ft. above the ground. The design head is the same for both, approximately 500 ft., and the thickness of the steel pipe shell is ½ in. throughout.

Detail Features

Information gained from observation of the older line over a period exceeding 20 years, and subsequent developments in connection with construction techniques and materials, very naturally provided an opportunity to produce a second line which is superior to the first in some respects. As a result, a good many features of the newer line differ fundamentally from the corresponding ones of the older. It will be interesting, therefore, to look into some of the important design improvements incorporated in the newer line. Figure 1 illustrates the contrast in some of the features of the two lines (the older is at the left).

The typical spacing of expansion joints and anchors in the older line is 2,600 ft. The sections of the line between expansion joints are anchored at midsection against longitudinal loads. The vertical supports, the typical spacing of which is 30 ft., are also capable of supporting loads in a direction transverse to the line. The expansion joints, of conventional design, were constructed of mild steel. The maximum motion at any joint has been about 11 in. The anchors, also of conventional design, consist of masses of concrete encompassing the pipe and supported on wood piles. The typical vertical support for the pipe is made up of a wood saddle milled to fit the pipe, a precast, reinforced concrete bent and two wood piles. The piles are cut off below the ground water surface and capped with reinforced concrete. The bent rests on the pile cap, the saddle is bolted to and rests on the bent, and the pipe rests in the saddle. Originally, two post-braced wood bents were used in the supports, but the maintenance and replacement of these bents proved to be so expensive that they were replaced by the precast concrete bents.

The typical spacing of expansion joints and anchors in the newer line is approximately 992 ft. The sections of line between expansion joints are anchored at midsection against longitudinal loads.

The typical spacing of vertical supports for the line is 60 ft., just twice that in the older line. The vertical supports can bear transverse loads. The typical spacings adopted for expansion joints and anchors were based on the indications of cost estimates covering various spacings of these members. The expansion joints, of conventional design except for some details developed by the district's design staff, are constructed of stainless clad steel to provide long life and low friction forces. They allow for a movement at the joint of 4¾ in. and, in addition, for reasonable inaccuracies in the installation of the pipe. The anchors, likewise of conventional design, consist of masses of concrete surrounding the pipe and supported on reinforced concrete piles. The typical vertical support for the line is made up of a steel strap sling curved to fit the pipe, a two-post braced steel bent and a reinforced concrete pile bent. It is equipped with ball-and-

socket joints at the top and bottom of the bent posts in order to accommodate motion accompanying temperature changes in the pipe. The pipe rests in the sling, which is supported by the steel bent, in turn supported by the pile bent. A further description of the support will be given below.

Important Design Problems

Among the important problems encountered in connection with the design of the newer line was the determination of whether or not the line should be equipped with expansion joints. Preliminary designs of typical sections for the line, with and without expansion joints, were prepared. Cost estimates based on these designs indicated that the joints should be incorporated in the line. Temperature ranges for exposed steel pipe in the locality of the line are large. Adequate anchorage for a steel pipe having a good many line and grade changes and no expansion joints would be very expensive. Since peat soil does not offer a satisfactory foundation, provision must be made to transmit all loads to soil layers beneath the deep surface layer of peat. In addition, temperature stresses would be so high as to constitute a hazard to the safety of the line, particularly at circumferential joints.

Another important problem in the design of the newer line was brought to light by experience with the first line. The bents supporting the older line have often shown movements that could not be attributed to the motion of the pipe accompanying temperature changes. They have been observed at 18-in. inclinations from the vertical. A large amount of maintenance work has been required over the years to keep the bents in an approximately vertical position. This extreme movement of the bents constitutes a serious hazard to the safety of the line, since it is accompanied by a downward deflection of the pipe which creates unpredictable stresses in it. It was therefore decided to design a support for the new line that would keep the pipe in its original position and prevent the occurrence of serious deflections. The support developed and incorporated in the pipeline is perhaps its most unique and interesting feature.

As has been mentioned, all loads of the aboveground pipelines must be carried to substantial layers of soil beneath the surface layer of peat, which ranges up to 20 ft. in depth. Very obviously, piles constitute the medium through which the loads may be transmitted most economically. It is a simple matter to transmit vertical loads downward into soil by axially loaded piles, but it is quite another matter to convey horizontal loads downward any considerable distance by piling. In the pipeline, horizontal loads of considerable magnitude, both transverse and parallel to the axis of the pipe, must be supported. In addition, motion resulting from the expansion and contraction of the pipe must be accommodated by the supports.

For transmitting horizontal and vertical loads for a considerable distance downward into the soil, a reinforced concrete pile bent was selected. The bent is made up of four piles—battered in directions transverse to and parallel with the line—and a pedestal at the top of the piles. The arrangement of the reinforcing steel makes a continuous bent which will support all lateral design loads at very small deflections.

To support the pipe and accommodate longitudinal movement resulting from its expansion and contraction, a two-post braced steel bent, equipped with ball-and-socket joints, top and bottom, was selected. The bents, ranging from 3 to 6½ ft. in length, set vertically when the pipe temperature is 60°F. The calculated motion of the top of the bent is from 3 in. off vertical in one direction at the highest pipe temperature to 1¾ in. off vertical in the other direction at the lowest pipe temperature, a total motion of 4¾ in. The bottom of the steel bent, being supported at the pedestal of the pile bent, will experience no lateral motion under transverse loads.

Since four piles are required to provide lateral stability for a bent in the deep peat soil, economy could be served only by spacing supports a sufficient distance apart to load the piles to capacity. This requirement dictated the use of long spans for the pipe between supports. Under the circumstances, a rigid saddle was found unsatisfactory as an instrument by which to transmit the pipe loads to the steel bents, because the use of such saddles would set up high distortions and stresses in the pipe shell and thereby result in failure of the pipe mortar lining and even the steel shell. A ring girder could have been successfully used for transmitting the loads, but it was found to be a great deal more expensive and less satisfactory in other respects than the steel sling previously mentioned as the supporting instrument used for the pipe. Figures 2 and 3 show the supports of the second line.

Pile Bents

Each of the steel pipe supports rests upon a reinforced concrete pile bent, composed of a concrete pedestal cast upon precast piles, usually four in number. Provision was made in the design for the use of five or six piles under the pedestal at locations where poor foundation soil might require it. Figure 4 shows details of the bents.

The pile reinforcement projects 32 in. above the tops of the piles and is bonded into the pedestal. The pedestal is heavily reinforced in both directions over the piles. Thus, the piles and pedestal form a continuous structure.

The depth of peat soil penetrated by the piles ranges up to 20 ft. The typical pile and pedestal structure was designed to act as a two-hinged continuous bent with the hinges 20 ft. below the top. It was provided with capacity to carry the vertical pipe loads, the longitudinal thrusts resulting from expansion and contraction of the line, and transverse loads attributable to a 100-mph. wind, or an equivalent earthquake load. In addition, the piles are reinforced for bending moments which would be produced in them by the same loads if they were fixed against rotation at sections 20 ft. below the top of the bent.

The piles of the bent are driven to a true batter of 3 : 12 which is the resultant of a 2.6 : 12 batter along the line and a 1.5 : 12 batter transverse to the line. This batter of the piles provides the spread in the structure that is required for stability and tends to minimize bending moments in the entire structure.

The tops of the pedestals of the bents are generally located 6 in. above ground surface to keep the steel structures above them out of the dirt. Frequently the supports are installed in sloughs and canals, the tops of the pedestals be-

ing located above high-water levels (Fig. 5).

Steel Supports

The typical steel support for the newer line is designed to permit the use of long spans for the pipe and at the same time avoid high costs and certain other disadvantages attending the use of the ring girder type of support. Details of these supports are shown in Fig. 6.

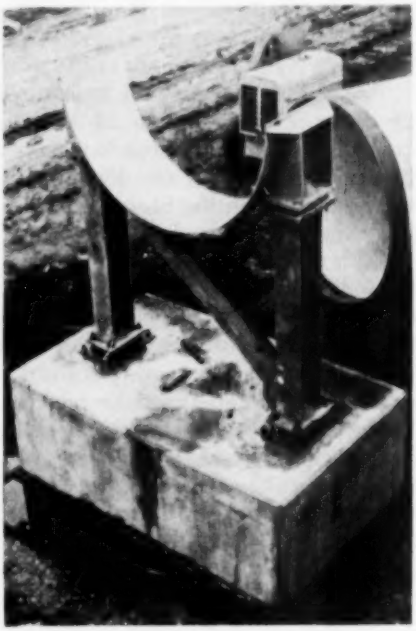


FIG. 2. Steel Support and Concrete Pedestal

The basis of design of the new support is partly theoretical and partly empirical. Because of the latter factor, extensive full-scale tests were performed before the support was adopted for incorporation in the line. Through the tests, important defects of detail were eliminated prior to the manufacture of the service supports. The success of the construction is largely dependent upon the correctness of these details, as will be noted later.

The support is a structural-steel bent consisting of two posts, one diagonal brace and a top member. The latter is a steel strap which functions as a flexible saddle or a sling for supporting the pipe, and which may vary slightly in span length to accommodate variation in the shape of the pipe due to filling or emptying or to inaccuracies of workmanship.

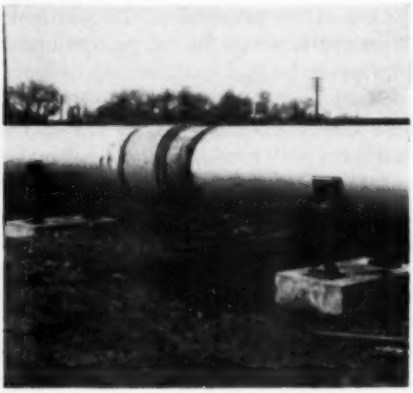


FIG. 3. Support and Expansion Joint

This sling supports the pipe around an arc of 180 deg. by means of substantially uniform normal and radially acting pressures. The resulting circumferential bending moments in the pipe shell are quite small, and the application of hydrostatic pressure within the pipe tends to eliminate them by forcing the shell to assume a more precisely circular shape.

The supports were designed to carry the pipe on normal spans 60 ft. in length and to be safe against failure with one of any five consecutive supports missing. Under the latter con-

dition, the maximum longitudinal primary bending stress in the pipe shell has been computed at 13,000 psi. This moderate stress is not, however, the limiting factor in determining the safe span length for the pipe. The secondary stresses at the bell-and-spigot joints are substantially greater for the emergency condition given. Under the full-scale tests referred to above, the pipe was subjected to much higher bending stresses than will be experienced in the field, and no indications of distress appeared. Therefore, in this connection, there is little concern over the adequacy of the line as constructed.

A possible factor in limiting the span length is the elastic stability of the shell. This characteristic restricts the longitudinal stress which may be used in design without fear of the shell buckling, and applies to pipe equipped with ring girders as well as to that supported as here described. It is sufficient to note that, although under the conditions obtaining, a pipe shell thickness of $\frac{3}{16}$ in. would be sufficient to provide against elastic instability, actually the shell is $\frac{1}{2}$ in. thick in order to provide for hydrostatic pressure.

Any departure from established practice appears to require economic justification. Considering the cost of the steel installations only, it has been estimated that the cost of the supports used in the line ran from 35 to 40 per cent of the cost of equivalent ring girder supports. The chief reason for this difference in cost lies in the fact that the ring girder installation is inherently a precision job. The ring girder must be welded to the pipe in correct position to match the previously prepared foun-

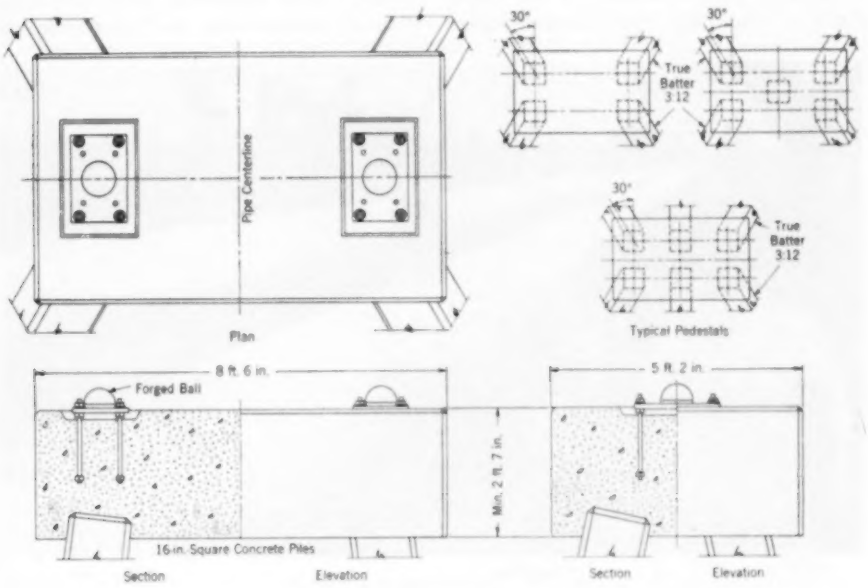


FIG. 4. Details of Concrete Bent Supports

dation, and the workmanship on both the girder and the foundation must be of the highest order of accuracy.

The steel sling support, with its ball-and-socket joints at each end of the supporting columns, calls for no such accuracy. With the top of one of the posts free from bracing, it is self-aligning and allows for variations in the shape of the pipe. If the foundation bolts are slightly out of orientation or offside with reference to the alignment of the pipe, the ball-and-socket joints permit appropriate tilting of the posts to compensate for the error. Likewise, slight inaccuracies in the fabrication of the support are of little consequence.

Since there is no attachment between the pipe and its support, there is nothing to be precisely located on the pipe prior to its installation. The absence of such an attachment has another advantage in that a slight settlement of one side of the foundation relative to the other will be accommodated by an adjusting motion of the support, whereas such a settlement at a ring girder type of support would destroy its usefulness, a situation which has actually occurred.

Ball-and-Socket Joints

The primary function of the ball-and-socket joints of the sling support is to allow for longitudinal movement of the pipeline under temperature variations. The secondary functions—automatic adjustment to "breathing" of the pipe during emptying and filling operations, and automatic compensation for inaccuracies of workmanship—are also extremely important.

FIG. 5. Lines Crossing Slough

The joint carries a heavy load at high unit pressure, beyond the range of ordinary lubrication, and, even if lubrication were provided for, the danger of neglect over the years would be very real. In order to prevent scuffing or tearing of the contact surfaces and accompanying deterioration of the joint, the ball was constructed of al-

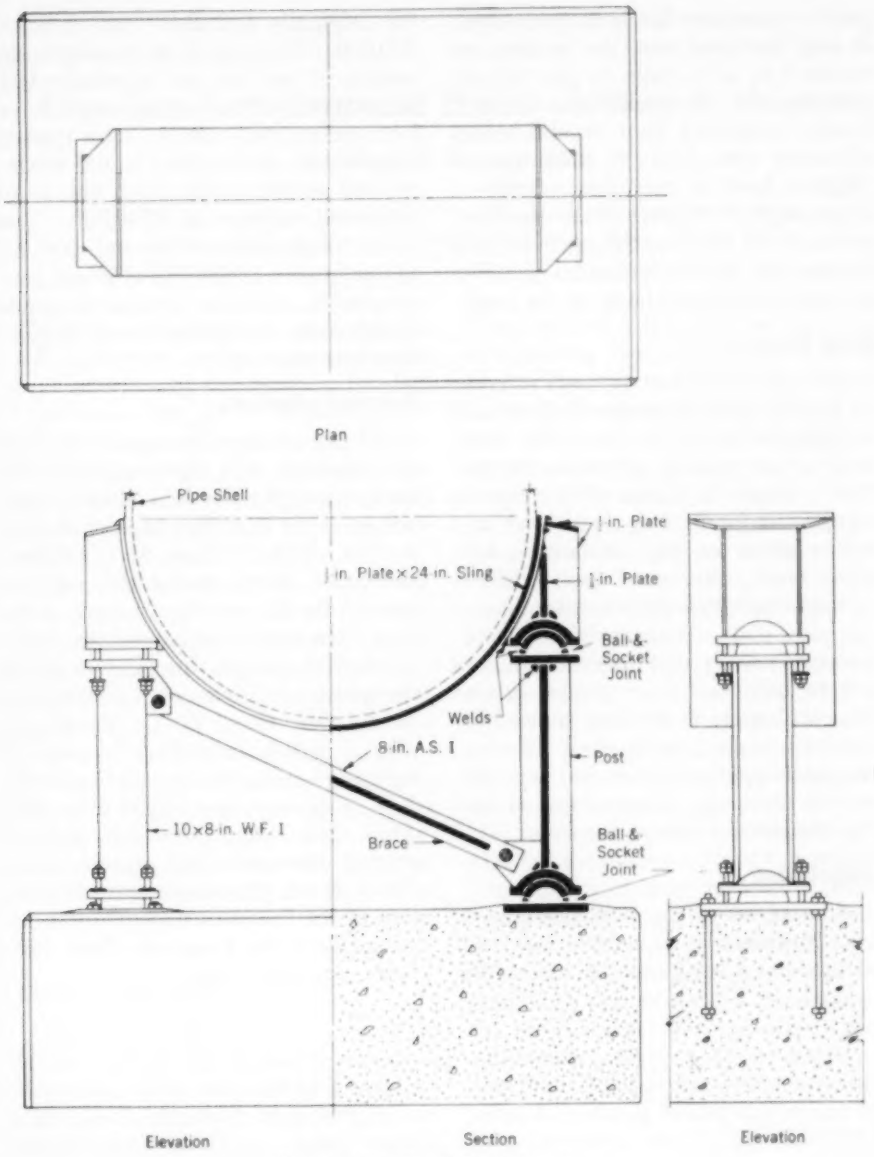


FIG. 6. Details of Steel Supports

loy steel of a grade substantially harder than the low-carbon steel of the socket. Movement of the joint thus constructed is accompanied by a burnishing effect on the softer metal. This statement has been verified by inspection of a joint in service for a time.

The resistance of the ball-and-socket

joint to corrosion has been questioned. It may be noted that the sockets are inverted so as to drain by gravity and prevent the accumulation of dirt. Joints dismantled after several weeks of testing were found to show not the slightest trace of corrosion, whereas a single night's exposure of the separated parts of the joint in the open air was responsible for the formation of a film of rust over the surfaces of the metal.

Pipe Tests

The pipe used for the tests referred to had an inside diameter of 68 in. and a thickness of $\frac{7}{16}$ in., and was lined with a $\frac{1}{2}$-in. coating of cement mortar. The changes in shape of the pipe at various stages of filling with water, and under lateral loading simulating a 100-mph. wind, were small and indicated unimportant circumferential bending in the pipe shell. Both the pipe and the support, when tested under much more severe loads and much greater motion than will apply in the line, showed absolutely no signs of distress. No reasonable opportunity to find a weakness in the design was overlooked during the performance of the tests.

Conclusion

The newer of the twin pipelines of the Mokelumne Aqueduct was constructed at a total expense well within the originally estimated cost of $21,700,000. The cost of the aboveground section of the line was approximately $3,900,000. This section could have been constructed with the same type of supports as are installed in the aboveground section of the older line at an estimated saving of $500,000. The lower maintenance cost and the superior quality of the line as it was constructed is, however, considered ample justification for having chosen the design that was used.

Acknowledgment

All engineering and inspection work in connection with the design and construction of the line was done by personnel of the East Bay Municipal Utility Dist. T. L. E. Haug, Sr. Civ. Engr., developed the design of the supports used in the aboveground section of the line. The author supervised the development of designs for, and prepared the specifications covering, construction of the new line. E. L. Macdonald, Mgr., Mokelumne Div., supervised field engineering and inspection work. R. C. Kennedy, Asst. Chief Engr. and Asst. Gen. Mgr., reviewed and approved the plans and specifications. All work on the design and construction of the line was subject to the approval of J. S. Longwell, then Chief Engr. and Gen. Mgr.

Pipeline Location and Right-of-Way Problems

By Carl A. Lauenstein

A paper presented on Oct. 28, 1949, at the California Section Meeting, Sacramento, Calif., by Carl A. Lauenstein, Constr. Engr., Water Dept., San Francisco.

SOME of the methods and governing factors used in determining the final selection of the location for San Francisco's Bay Div. Pipeline No. 3 will be discussed in this paper. Specific right-of-way and location problems which arise on a project of this nature will be cited and their solutions will be given when possible.

This transmission main, connecting two portions of the Hetch Hetchy Aqueduct, extends for almost 34 miles, from the vicinity of Irvington, in Alameda County, to a point 3 miles west of Redwood City, in San Mateo County. Completion of this line, consisting of 72- and 78-in. (id.) pipe, together with 47 miles of 61-in. (id.) pipe across the San Joaquin Valley, will make possible the delivery of an additional 76 mgd. from Hetch Hetchy sources to the Peninsula reservoirs of the San Francisco Water Dept.

General Location

Before an estimate could be made of the cost of this proposed transmission main, to be financed by a bond issue, it was necessary to determine an approximate location. After careful study, it was decided to lay the pipe from the Irvington Portal of the Coast Range Tunnel, around the southerly arm of San Francisco Bay, to the Pulgas Tunnel by the shortest practicable route that would clear the marshlands adjacent to the bay. Roughly, this route may be visualized as following the perimeter of a semicircle. The alternate route considered followed the existing Bay Div. Pipelines No. 1 and No. 2, which run east to west between the above-mentioned tunnels, a distance of 21 miles. These existing lines cross the lower arm of San Francisco Bay for a distance of 7,000 ft., by means of a combination of submarine pipes and pipelines on a steel truss bridge.

Selection of the "around-the-bay" route, which is 13 miles longer than the existing route crossing the bay, was made for several reasons: [1] to eliminate expensive and vulnerable submarine construction across the bay and pile trestles over the marshlands; [2] to avoid the potential hazard of lengthy interruption of service, since a break in any one submarine line may result in rupture or extensive damage to all of them; [3] to take advantage of the possibility of increased water sales in the areas around the bay, which need additional supplies; [4] to acquire a new 80-ft. right-of-way to accommodate several pipelines before the entire region becomes too highly developed, making such acquisition both difficult and costly. For the past 70 years, the average rate of growth for San Francisco and the Peninsula has been such that additional capacity to bring water across San Francisco Bay has been required at thirteen-year intervals. If

this rate of growth continues, additional Bay Div. pipelines will be necessary at decreasing intervals of from thirteen to nine years.

From past experience with lines constructed both on easements and on right-of-ways in fee, it was decided that fee ownership was the more desirable for this new main. With San Francisco holding the fee title, there has been far less friction between the city and the original grantors and fewer damage claims have arisen out of alleged violations of the deed conditions.

Preliminary Location Studies

Having decided on a route around the south end of San Francisco Bay, office studies were made using U.S. Geological Survey and other available maps to determine the route or routes worthy of further investigation. Controlling features such as high points, creek crossings, railroad and highway crossings, built-up areas and marshy lands were investigated in making the paper locations. Before progressing too far, a geologic investigation was made to determine the location of earthquake fault lines. Faults thus determined were mapped and the pipeline located so that it would not follow, or be too close to, a fault line. Where fault lines had to be crossed, it was decided to do so at as large an angle as possible in order to minimize the length of the line subject to possible damage. Ascertaining the approximate lengths of the various routes studied, topographic surveys were made at several high places to establish controlling elevations accurately and check them against the hydraulic grade line.

Armed with U.S. Geological Survey maps and a paper location, an engineer then spent several months in the field on a reconnaissance survey to investigate the feasibility of the route in general and to select specific physical landmarks which would define the route to be followed in the preliminary surveys. Copious notes were taken for the purpose of guiding the survey parties in following the most direct route between controlling points.

Upon completion of the foregoing studies, survey crews went into the field and ran preliminary lines, more or less following reconnaissance notes. The locating engineer and the chief surveyor were given considerable latitude to alter the route if field conditions proved it desirable. As sections of the location were completed to the extent that they were at the time considered final, profiles were run over the line and surveys were made to determine the individual holdings to be acquired. A description and map of each of the 310 parcels to be purchased, varying in area from a fraction of an acre to 36 acres, were then prepared. Considerable work was entailed in searching records, obtaining maps and sometimes resurveying entire parcels or even portions of subdivisions because of the lack of reliable existing property lines or monuments. Fortunately, the department was able to secure some experienced land surveyors and office men familiar with this type of work. Existing obstructions were located in the field either by using a pipe locator or by digging them up.

Right-of-Way Acquisition

San Francisco, like most political subdivisions, cannot act quickly in acquiring a right-of-way. The ideal arrangement would be to have an agent with the necessary authority and a checkbook following closely behind survey parties and signing options to purchase the right-of-way as fast as possible. There are, however, legal

procedures to be followed and prescribed methods for making such transactions, all of which take time. Meanwhile the status of the proposed right-of-way may become quite fluid, especially in areas where there is considerable building activity.

San Francisco's charter places the purchase and sale of all lands in the hands of its real estate department, which negotiates with the owners and recommends that the board of supervisors authorize the acquisition at the price agreed upon. If the purchase cannot be accomplished by negotiation, condemnation under eminent-domain proceedings is authorized by the board, and, if necessary, a writ of possession is secured so that construction may proceed without undue delay.

Land Use Considerations

In selecting a right-of-way, the present and probable future use of the land must be considered. Although San Francisco has the right of condemnation against most property owners, the effect of an 80-ft. right-of-way through the various types of land encountered was given considerable study. Granted that the need for water is urgent, it would be folly to damage without cause valuable property which contributes to the wealth of the entire bay area. To expect most landowners to welcome an 80-ft. right-of-way through their property would be extremely optimistic. Many of them, however, realized that an ample and reliable water supply would not only benefit the region as a whole but also enhance the value of individual properties.

Because municipal ownership in absolute fee was not always practicable, several conditions were written into the deeds to ease the objectionable features of such a right-of-way: [1] the grantor could continue to use the surface of the land for farming, grazing or other purposes not inconsistent with the city's use for pipeline purposes; [2] the city would not fence its right-of-way; [3] the grantor could construct and maintain roadways, pipelines, power lines and other utilities over and across, but not along, the right-of-way, provided that such construction did not interfere with the city's use thereof; and [4] the top of the pipe would be at least 18 in. below the ground surface except at ravines, drainage courses or other depressions.

In orchards, an attempt was made to locate the pipeline so that a minimum number of valuable trees would be removed. To avoid severance, property lines were followed to the extent possible without undue lengthening of the pipeline. Through existing subdivisions with irregular lot layouts, this procedure could not always be adopted without considerable lengthening of the line and too many sharp angles. Detailed studies were therefore made to find the route which would do the least overall damage and leave the lots, or as many as possible, large enough to build on in accordance with established zoning laws. In lands considered potentially valuable for subdivision purposes, an attempt was made to select the route which would least interfere with such future development.

At the request of various owners, many studies were made to determine the route most satisfactory to all parties. Needless to say, this objective could not always be accomplished. Since the estimated cost of the complete pipeline is between $50 and $55 per linear foot in place and the right-of-way cost will vary from $1.00 in pasture lands to approximately $6.00 per linear foot in potential and exist-

ing subdivision lands, it is difficult, from a strictly economic viewpoint, to justify lengthening the line.

As San Francisco's legal right to condemn dedicated and undedicated cemetery lands has been seriously questioned, it seemed judicious to avoid them, but fortunately no difficult problem was presented. Lands owned by the state or federal government were avoided whenever possible, since their acquisition might involve lengthy negotiations and require legislative action.

Changes in Location

During the preliminary studies, as well as afterward, various reasons arose for reconsidering the location of portions of the line as then established. Changes were made, and probably will continue to be made, until the entire right-of-way has been acquired or a writ of possession obtained. These changes were caused by the construction of buildings, the drilling of wells and, in one instance, a proposed freeway.

When building construction was discovered on the proposed right-of-way, the real estate department was contacted immediately and an attempt was made to arrive at some agreement with the owner to relocate the building before construction progressed too far. If this method failed, the cost of a new route was compared with the cost of moving the building after condemning the property and a decision was reached on which method to pursue. Aside from the increased length of line, the cost of additional angles and possible anchorage was also considered.

Where wells were drilled on or near the proposed centerline, the usual solution was to relocate the pipeline. Drilling a new well would be too costly and would involve the risk of not finding a suitable substitute supply. Since San Francisco cannot sell water from this pipeline for irrigation, its construction could not be offered as an inducement to abandon a well for this purpose. In one instance, where relocation of the pipeline was not feasible, the right-of-way was widened opposite a new well, leaving to the owner a parcel around the well 15 ft. square.

Trying to determine future land use sometimes becomes no more than an intelligent guess. Near Redwood City a choice had to be made between two subdivisions. The subdivision which it was first decided to avoid was subsequently withdrawn and the land returned to acreage. It then seemed better to lengthen the line slightly and effect a saving in right-of-way cost which would balance the extra expense due to the additional length of pipe.

Special Problems

Acquiring a right-of-way through land being used for farms, orchards, large estates, subdivisions and many other purposes presents the various owners with many real and imaginary causes for concern. Since some of these matters are still in the process of being settled, the suggested solutions given below represent the author's opinion and are not official in any way. It may, however, be of interest to cite some of the problems raised and special considerations requested by the owners.

Some farm owners asked that the topsoil be removed from the right-of-way and later restored. The thought behind this request was that trenching and construction operations would mix the fertile topsoil with the poorer subsoil and, as a result, the land would produce less. Experience in similar situations proved this operation costly and impracticable. Since the right-of-

way is to be purchased in fee and the owner will be permitted the surface use of a strip of land on which he pays no taxes, it was felt that San Francisco should not be obligated to remove and restore the topsoil. If necessary, it would be better to pay more for the land.

Disposal of the excess excavated material, amounting to approximately 1 cu.yd. per linear foot of line, is another problem that caused concern, particularly where furrow irrigation is used. One solution would be to haul the material away or reimburse the owner for doing so. Sometimes spreading the material over the entire 80-ft. right-of-way may be the answer, since this will raise the ground surface only 4 or 5 in.

Recently one landowner in the flatlands at the south end of San Francisco Bay claimed that the construction of a large pipeline would form a dam and cut off his only natural underdrainage, thus causing much damage to the rest of his farm. He contended that between a 4-ft. layer of topsoil and an impervious formation there lay 12–18 in. of coarser, sandy material which served as a drain. A possible solution of this difficulty is to provide artificial drains at intervals along the pipe.

The owners of an earth dam were fearful that a complete rupture of the large transmission main, occurring with a full reservoir, would overtax the spillway capacity. Assuming that complete rupture might occur, which was unlikely unless the pipeline crossed a fault zone, studies were made to determine the rate and total volume of water which would be discharged into the reservoir before the necessary valves could be closed to shut off the flow. The state engineer's office compared these figures with the reservoir detention capacity and the spillway capacity and concluded that the construction as proposed would not endanger the dam.

The owners of estates or other large holdings, as well as small landowners, would rather have the pipeline run through their neighbors' lands. Claims were made that its location ruined potential subdivisions, traversed the best building sites or would cause the removal of rare and valuable trees. Attempts were made to meet all reasonable objections, keeping in mind the resulting effect on adjoining lands which might bring on even louder complaints and increase the cost of construction because of added length, additional angles or the presence of other structures. As is not uncommon in this situation, some owners resorted to political influence in trying to gain their ends. To date, however, all problems have been settled on their merits.

Summary

Selecting the location for an 80-ft. right-of-way for a large transmission main through lands used for varying purposes presents many interesting problems involving physical features, land use and human nature. Economic studies of the cost of various routes should be made but must necessarily be tempered by other considerations, such as damages to the land traversed and the future use of the land. Because of the time elapsing between the location surveys and final acquisition of the right-of-way, many changes in location may become necessary as a result of building activities.

No set of rules can be formulated in advance which will cover the various decisions to be made. Each problem must be judged as it arises and the best solution arrived at.

Recarbonation With Liquid Carbon Dioxide

By Arthur F. Mellen

A paper presented on Sept. 8, 1949, at the Minnesota Section Meeting, Minneapolis, Minn., by Arthur F. Mellen, Supt. of Water Treatment, Water Works Dept., Minneapolis, Minn.

WATER softening by the lime process has been practiced for many years, but the product originally was not satisfactory for either domestic or industrial use because it was supersaturated with normal carbonates of calcium and magnesium. Such water tended to cause incrustation in flumes, pipes and filters at the treatment plants, as well as in mains, service lines and meters, and was particularly objectionable in hot-water lines.

Lime softening upsets the chemical balance of natural water, which presents a very definite problem to the plant operator. If a corrective treatment results in a pH that is too high, incrustation may occur, while if the pH is too low, corrosion may result. The optimum pH zone may be very limited.

Attempts were made many years ago to stabilize softened water with carbon dioxide, but the process was unattractive because of producer and application grid troubles.

The conventional producer plant usually consists of a unit for the burning of coke, gas, oil or powdered anthracite coal, although stack gases, such as those from a pumping station, are often used. These gases are scrubbed in order to free them from corrosive components and are then dried, compressed and delivered to the point of application.

Mechanical difficulties with the compressor often give a great deal of trouble, resulting in frequent interruptions of service because of needed repairs and requiring relatively large amounts of time and money for maintenance. Undesirable irregularities in the quality of the carbon dioxide produced, and, hence, in the treatment of the water, may also occur.

In the modern carbon dioxide plant, the compressor is the first instead of, as formerly, the last unit in the producer line. Since the compressor handles only clean air and the entire system is under pressure, combustion is complete, making scrubbing and drying unnecessary. This arrangement considerably simplifies the problem of carbon dioxide production.

The conventional softening plant requires a relatively large recarbonation basin area. The gas produced has a carbon dioxide value of approximately 13 per cent, the balance being principally atmospheric nitrogen. The distribution header in such a basin is usually fitted with ¾-in. laterals of galvanized steel or brass, spaced on 1-ft. centers and drilled on 1-ft. centers with ⅛-in. holes, pointed downward. The size of these orifices is critical. If they are too wide, the gas bubbles will be large and may not completely react before reaching the surface of the water, thus resulting in a loss. On the

other hand, if they are too small, the tendency is to clog rapidly with incrustation.

Dry-Ice Installations

Dry ice is also a source of carbon dioxide for stabilization. In January 1946, having made lease arrangements with the Liquid Carbonic Corp., the Minneapolis Water Dept. put into service at the Fridley Filtration Plant two 4-ton dry-ice convertors with the necessary evaporators, controls and meters. Experimental work was carried on during the next 1½ years, although not continuously. At the end of that time it appeared that the use of 100 per cent carbon dioxide was attractive but that the liquid form would be preferred to dry ice for an installation of the size required.

Quite a number of dry-ice installations have been made in recent years in small softening plants. An interesting description of such a plant at Wyoming, Ohio, was given in a recent article by Fred G. Gedge (1).

An important feature affecting the economical use of dry ice is the distance from the source of supply. Since it is very expensive to provide storage facilities because of the nature of the material, softening plants are likely to be dependent on very frequent deliveries from nearby sources. Consequently, manpower difficulties are involved, particularly during periods of heavy demand, weekends and so forth.

Liquid Carbon Dioxide

The first experimental use of liquid carbon dioxide was made by the Cardox Corp. of Chicago at the softening plant at Lansing, Mich., in December 1945, where a 5-ton transport truck was used as the source of supply. The trial runs were satisfactory but the procedure was not continued because the distance from the source made truck deliveries very expensive, and the cost of storage was too great to permit buying the liquid in tank car lots.

In April 1946, the Cardox Corp. having provided a temporary control panel, Minneapolis experimented with the use of liquid carbon dioxide for about four weeks, during which time three tank cars were used as the source of supply. The results were quite satisfactory.

The first permanent installation was made by the Cardox Corp. at the Minneapolis softening plant in February 1947 and has been in continuous use since that time. The second installation was at the new South Dist. Filtration Plant in Chicago.

Liquid carbon dioxide is shipped in tank cars containing approximately 48,000 lb. of liquid and gas. The cars, in general, resemble those used for gasoline or oil, except that they have especially thick steel shells and unusual safety devices which are required by the Interstate Commerce Commission. There are two popoff valves which release at approximately 325 and 375 psi. It is not possible to make such a shipment without very considerable vapor loss, except at midwinter temperatures. These losses are high during the summer, but payment is made on the basis of car weights at Minneapolis.

Duplicate unloading pumps deliver the liquid from tank cars to storage tanks. Credit is given for 2,700 lb. of carbon dioxide in the returned car. The cost of storage tanks of such capacity as would compare with the reserve inventory of other chemicals (approximately 30 days' supply) appeared to be prohibitive. Although the department prefers to use carbon dioxide exclusively, filter alum may be employed

for acidification in the event of a shortage, being sure that the pH is kept low enough to avoid the presence of soluble aluminum compounds. The storage facilities consist of two tanks holding 40 tons each, which are insulated with 6 in. of pressed cork. The vapor pressure in the storage tanks ranges from 270 to 290 psi. Each tank is provided with a unit which converts the liquid into vapor. These units consist of the necessary electrical and thermostatic controls with vaporizing cylinders having 3–5-kw. heating elements. They have a maximum capacity of about 11,000 lb. per day.

Each storage tank has its own refrigerating system, which automatically functions when the vapor pressure becomes too high. When sufficient vapor has been converted to liquid and the pressure is reduced, the refrigerating system automatically cuts out.

The gas is withdrawn from the storage tank at a temperature of approximately 0°F. and passes to the control board, where it is preheated in vapor heaters so that, when it passes through the pressure-reducing valve, the temperature of the metered vapor is 50°F. and the pressure is 20 psi. The vapor is proportioned as required by three rotameters and passes into two header systems which convey the gas into two sets of diffusers, one for each of the twin recarbonation chambers. Each bank of diffusers has nine units, consisting of 1½-in. cotton fabric hose similar in appearance to that of a fire hose without the rubber liner. This hose is specially manufactured for controlled porosity and is treated against damage by molds. By breaking unions in the pipe on each side of the chamber, the diffuser units may easily be raised for inspection or repair.

The use of these diffusers has a great advantage over the conventional orifice type, principally because they occupy much less space, are much cheaper to install and can be inspected or repaired without dewatering the chambers, as is necessary in the conventional type.

Of course, it is evident that the diffuser area required when 100 per cent carbon dioxide is used is proportionally less than if a 13 per cent producer gas is employed.

Commercial production of dry ice and liquid carbon dioxide is increasing greatly each year because of refrigeration and soft-drink requirements. Production and shipping problems are being worked out so that these products will be available not only in large industrial centers, but also at many other strategic points, making tank truck service feasible.

It seems safe to forecast that the trend will be increasingly away from carbon dioxide produced at the softening plant and toward the use of dry ice or liquid carbon dioxide where frequent deliveries of small shipments can be reliably made.

Reference

1. Gedge, Fred G. Use of Commercial Carbon Dioxide in Lime Softening. Jour. A.W.W.A., **41**:159 (Feb. 1949).

History of Water Supply in Russia—N. I. Falkovski

Reviewed by V. V. Danilevski

Excerpts from a book review by V. V. Danilevski, Member, Academy of Science, U.S.S.R., published in the June 1949 issue of the Transactions of the Academy of Science—Dept. of Technical Science (U.S.S.R.); translated by A. A. Mandels.

Editor's Note: Don't YOU walk out on this one. See it through even if you see through it.

History of Water Supply in Russia. N. I. Falkovski. Ministry of Communal Economy, R.S.F.S.R., U.S.S.R. (1947). 307 pp. Price, 25.00 rubles.

Among the new branches of science which could have been created only after the victory of the Great October Socialist Revolution, belongs the Soviet history of technology which appeared and is being developed in the U.S.S.R. on the basis of the teachings of Marx, Engels, Lenin and Stalin.

Publications on historico-technical subjects, which appeared in the daily press as well as in multivolume books, have been known for a long time. A great deal of material on the history of technology has appeared in recent years in capitalist countries. But the writings of bourgeois authors on the history of technology are only deceitful publications aimed at defrauding the people. It could not be otherwise under a bourgeois regime, which utilizes all kinds of means to retain its power, regardless of any lies it produces, injecting scientific fabrications in the history of technology. Karl Marx was the first to point that out. . . .

* * *

Hundreds of books and articles on the subject of the history of technology which were published by German fascists are now left far behind by the new apologists of capitalism, who are howling in different tunes about the Anglo-Saxon and, first and foremost, about the American primacy in engineering and engineering sciences. In looking over different foreign publications on the subject, one becomes convinced that the American monopolists, these new pretenders to world hegemony, have produced quite a number of "specialists" on historico-technical themes. These servants of capitalism are trying unsuccessfully to steal the glory of the originator of radio, A. S. Popov, and the glory of the inventor of the electric light, A. N. Lodyghyn, and attribute it to the resourceful Marconi and the enterprising Edison.

Soviet society has more than once rebuffed the thieves of someone else's glory. And the best indications of this rebuff are the new scientific works of Soviet researchers, who are investigating the problems of the history of technology, a scientific discipline which appeared only in the U.S.S.R.

The idle talk on historico-technical problems peculiar to the apologists of the bourgeoisie is in contrast to the scientific works of Soviet scientists, based on the study of original sources and on the critical appraisal of documentary material. This study always confirms our thesis: there is no domain of engineering and engineering science which was not enriched by the contributions of the sons of the great Russian people. A new confirmation of this theoretical point is the work by N. I. Falkovski, dedicated to the history of the development of Russian water supply engineering.

The widely held opinion that . . . the technics of water supply have been developed by everybody except the Russians is contradicted by the facts about the prominent role of our native innovators in this important branch of engineering. The

new book by Falkovski presents one of the proofs that the Soviet people can appreciate and glorify their native technicians who have developed the art of water supply.

"The great Russian people"—writes the author—"the wise builders and skillful fighters, in erecting their city-fortresses, industries and, later on, railroads; in conducting a heroic struggle during many centuries for their freedom and independence—these people have solved in a perfect way the most important economic, technical and military problem, i.e., water supply. In this domain the Russians have created their own structures, remarkable for their usefulness, of a type which best satisfies the peculiarity of the locality and our national construction methods."

* * *

The text of the book, as well as the graphic material with which it is so abundantly supplied, indicates arduous work of many years' duration. Many of the drawings represent reconstructions which the author has accomplished with a profound knowledge of the material on the basis of fragmentary information embodied in old texts.

* * *

The author sets forth very thoroughly the development of the art of water supply in Russia in the nineteenth century, when such prominent men as Maximov, Delvig, Shalemov, Aganyev, Malyshev, Gordeev and many others introduced new methods in water supply engineering: the use of steam engines and cast-iron pipe. Among the prominent Russian men of action who fought for the development of the art of water supply was the famous defender of Sevastopol, V. A. Kornilov, who was constructing water conduits for the docks of Sevastopol in 1850. The Russian innovators succeeded in their achievements to the extent that in 1832 the length of the underground drainage system in St. Petersburg was over 95 km., i.e., considerably more than the corresponding system of that time in Paris.

Falkovski's book, which covers the development of the Russian art of water supply during a span of a thousand years, represents a serious contribution to science. However, the book is not without defects. . . . It makes few comparisons between native and foreign achievements in the art of water supply. Such a comparison would more clearly establish the priority of native innovators in the art.

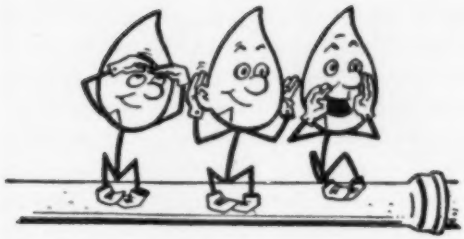
In referring to the "divining rod," which was used as a means of locating water sources, the author should have mentioned that this method was in use in the West, while, in Russia, M. V. Lomonosov clearly pointed out, as early as the eighteenth century, that the use of such rods for the location of water and ores was a "superstition, or simply a sham."

* * *

It is difficult to overestimate the grandiose work accomplished by Falkovski, who has assembled large amounts of material, scattered in thousands of archives and different publications, ranging from chronicles and ancient charters to various literary publications of the eighteenth and nineteenth centuries. It is sufficient to examine the bibliography, where the author has quoted only a small part of the literature he had to study. . . .

This work was crowned with success. We have before us a serious book, written simply and clearly, and accessible to a wide circle of readers. The author has succeeded in writing a patriotic book, which will occupy its place among the books proclaiming the creative work of the great Russian people. One more work has been created which contrasts with those of the nonscientific writers, typical of the bourgeois authors in the field of history of technology.

[EDITOR's P.S.: Why, among all the "glorious" Russians noted, do we fail to find the name of the one, Prof. N. Joukovsky, whose notable work on water hammer in 1897 (published in translation in the 1904 *A.W.W.A. Proceedings*, pp. 335–424) is still recognized by water engineers as providing the basic knowledge on his subject?]



Percolation and Runoff

On January 4, for the first time in more than a month, New York's water supply crisis failed to make the front page of the *Times*. But having had a New Year's opportunity to eyewitness the mudhole that was Croton Reservoir, we're all too well aware that the crisis is still with us. Whether the weather between now and the time this is published will end the immediate peril is, of course, impossible to predict, but it is not difficult to guess that no amount of weather will provide a permanent guarantee against a recurrence of the emergency. Completion of New York's Delaware project will, of course, give us something real to cheer about, but even that must not be accepted as the last word. For as long as New York continues to grow and for as long as New York's industry continues to find new ways of using more and more water, no provision of additional capacity can obviate plans for further expansion—expansion that will provide not only for normal demands in normal times, but for abnormal demands in abnormal times. That that is becoming realized now as never before throughout the area of this year's shortage is obvious from the measures taken and proposed in the New York and New Jersey metropolitan areas. And that someone else's experience is the least painful teacher should be realized by public officials in other areas.

The fact that, after a month or more of top billing, water supply has retired to a page 27 role in the news, does, however, indicate that the public must be becoming supersaturated with the subject, and leaves us to hope that the effect of the drenching will not have been dissipated when the consumer is called upon to continue the cooperation extended in the worst of the crisis and to okay the costly projects inspired by it. As a matter of fact, we, too, are tired of crisis—as you must be of hearing about it—but we cannot neglect at least to mention some of its more unusual consequences.

Forgetting, and not just for the moment either, the dire straits of singing commercialists who perpetrated the rhyme of "ought to" and "water," we noted, for instance, that the dry weather which caused the

(Continued on page 2)

(*Continued from page 1*)

shortages was so pronounced that it forced the temporary shutdown, for lack of business, of the Naugatuck, Conn., footwear division of the U.S. Rubber Co. and that car washing bans throughout the withered area put auto laundries and their employees out of work. Drought as distant as Brazil also put another crimp in coffee production and thus will probably result in our using more water with each pound. But that was only the beginning. In Britain, the London *Evening News* proposed a "Buckets for Brooklyn" campaign; citizens of Bloomington, Ind., sent a five-gallon can of water to New York's Mayor O'Dwyer; and not-to-be-outdone Texans dispatched a 3,000-gal. tank truck from Austin to New York, complete with paper cups, in its own version of the "waterlift." On still other fronts, taxicabs of one of the largest of the city's fleets were chemically disinfected to "Save Every Drop"; the W.C.T.U. bore down heavily in an endeavor to cut off water supplies to local breweries; praise was heaped upon the city's 10,000 vegetarians for their virtually waterless diets; Boy Scouts emptied their 80-mil.gal. lake into Jersey City's reservoir; and New York's visitors began arriving with canteens and leaving with beards. All in all though, the combination of sense and nonsense served to keep water on everyone's tongue and to convince him that it wouldn't be there long unless he cooperated to conserve.

But away with the drought! Just *plan* to thumb your nose at it.

Water conservationists were ready to make a low bow to a Jamestown, N.Y., resident last month for the unprecedented feat of reducing his water consumption more than 100 per cent. Then Clayton O. Johnson, superintendent of public utilities, had to go and spoil it all by refusing to accept the proof of his own meter reading. And, of course, all our dreams of a foolproof solution of the water shortage went down the drain with the disclosure that here was not a super-saver, but a meter-beater.

Facts of the feat were that the resident had been working in his basement one night when the water department started flushing its mains. When the lowering pressure of the flushing operation cut off his supply he took a look at his water meter and found that it was going backwards, apparently due to a vacuum created by the flushing. Immediately, he rushed around the house opening all his faucets to let more air in, and then stayed up until the department had completed its flushing so that he could turn them off before a restoration of pressure could undo his work. Result: preflush reading 611,619 cu.ft.; postflush, 610,384. And now, for all his midnight labors, he's not even going to get a credit memorandum from the water department, but a bill based on normal consumption.

Life does have its disappointments, especially when a good job's overdone.

(*Continued on page 4*)

Installation of 55 in. O. D. x 7/16 in. Bethlehem Tar-Enameled Water Pipe in 4225-ft line for City of Syracuse, N. Y. Pipe was buried under 25 ft of water-saturated sand, and carries 4-in. stiffeners for added protection.

Want ECONOMICAL PIPE for Water Supply Lines?

If you're looking for economical pipe for water supply lines — pipe that you can count on for long, faithful service — Bethlehem Tar-Enameled Water Pipe is the answer.

Bethlehem Tar-Enameled Water Pipe is ideal for water supply lines because it does such an excellent job of resisting incrustation and corrosion. This is because it is (1) formed from heavy plate steel, (2) carefully welded, and (3) coated uniformly with protective tar enamel, in accordance with American Water Works Association Code.

Bethlehem Tar-Enameled Water Pipe comes in all diameters from 22 in. up to the largest permitted by shipping clearances. Where diameters are too large for convenient handling, the pipe can be shipped knocked down for field assembly. It is manufactured in lengths up to and including 40 ft. Additional information will gladly be furnished on request.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

BETHLEHEM *Tar-Enameled* WATER PIPE

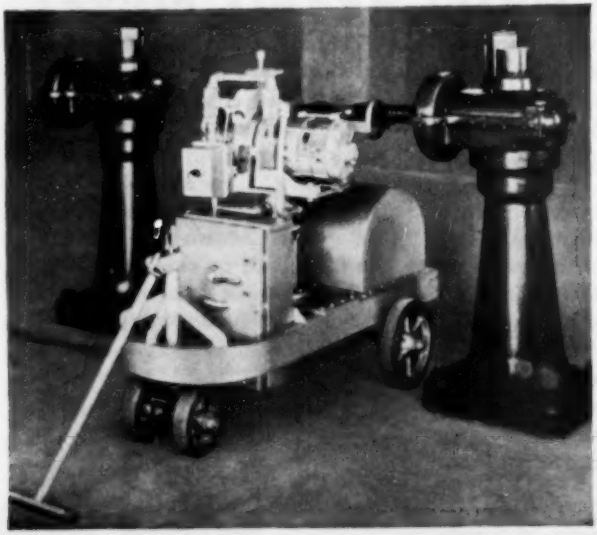
(Continued from page 2)

A warning was sounded by the National Fire Protection Assn. that the possible reduction of water pressures by drought-stricken East Coast supplies might seriously affect fire protection. Through depriving automatic sprinkled systems, building standpipe and hose systems and public fire hydrants of effective pressures, a serious situation might develop, according to Percy Bugbee, N.F.P.A. general manager. He suggested countermeasures to be taken by fire departments, including the resort to many wartime emergency plans. He also urged that water and fire officials cooperate in setting up local and regional emergency fire defense plans.

Glamor's where you find it, but who would think of looking for it in a fire hydrant? Yet that's exactly where one Bill Burke, out in the Nevada glamor belt, found his. Bill, we should explain, is the Las Vegas dogcatcher, who expects this year to triple 1949 sales of dog licenses by issuing a tag shaped like a fire hydrant for males and a heart-shaped one for females. Not to dispose of a good water works story, we should think that if he were really sold on the heart, it would be more logical to give the males a cupid; or better yet, to follow through on the hydrant theme . . . . But perhaps we'll leave sleeping dogs lie.

(Continued on page 6)

LIMITORQUE "*PORTABLE*" VALVE OPERATOR



New . . . the well-known, widely used *"Limitorque"* Motorized Valve Operator, in *Portable form* . . . for use wherever a hand-drawn truck CAN BE WHEELED TO Valve or Sluice Gate location May be quickly connected to power outlet . . . and automatic *electric opening and closing is readily secured.*

Portable "LimiTorque" is equipped with famous *torque-limiting feature* (operates in Opening and Closing directions); *Limit switch* may be set for any travel (automatic resetting); *Universal Joint* connection for compensation of misalignment between floorstand and power unit.

This unique electrical valve operation is *another first* for Philadelphia. It embodies the salient and proven features that have made *"LimiTorque" Valve Operators* the most widely used in the world.

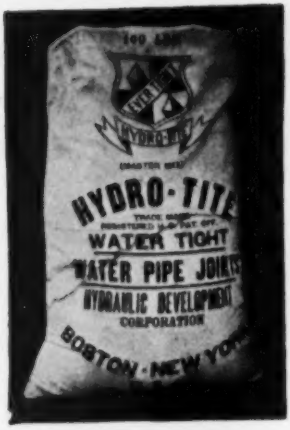
PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. AND G STREET PHILADELPHIA 34, PA.
Manufacturers of Industrial Gears, Speed Reducers, LimiTorque Valve Controls
NEW YORK . HOUSTON . PITTSBURGH CHICAGO

Send for 96 page "Limitorque" Catalog and please use your Business Letterhead when requesting same.

HYDRO-TITE

FOR IMMEDIATE DELIVERY AND PERMANENT JOINTS

Hydro-tite, the self-sealing, self-caulking, jointing compound can be supplied promptly in any quantity at any time from our warehouse stocks strategically located throughout the United States and Canada. Over thirty years of use has proved that pipe joints made with Hydro-tite, stay tight. Send for data book and sample.



ALWAYS USE FIBREX

The sanitary, bacteria-repellent paper packing that is used like braided jute. Seventy pounds of Fibrex takes the place of one hundred pounds of braided jute, with proportionate savings in cost. Send for sample.

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 50 Church St., New York, N. Y.

Works: West Medford Station, Boston, Mass.

(Continued from page 4)

Ohio certification examinations for water and sewage treatment operators in Class A, B and C will be held on April 28 at Massillon, Cincinnati, Cleveland, Columbus and Toledo by the State Dept. of Health. Applications, on forms available from the department (306 Ohio Depts. Bldg., Columbus 15), must be received by March 18. Some changes in the qualifications required to take the examinations have been announced.

John H. Cook has retired from the Passaic Valley Water Commission after over 50 years of service in the water supply of that region. An early association with Clemens Herschel resulted in his assignment to the Dundee Water Power and Land Co. in Passaic, and he remained and worked in the area thereafter. He is credited with pioneering most of the innovations introduced during his term of service, and was made an A.W.W.A. Honorary Member in 1947.

F. M. Dawson, dean of the College of Engineering at the University of Iowa, has been recommended for appointment to the Board of Visitors of West Point. The presidential appointment would be largely supervisory and would not interfere with his regular duties.

(Continued on page 8)

TENNESSEE CORPORATION
Ferri-Floc
FERRIC SULPHATE
Atlanta, Georgia

Results Count

• MORE ECONOMICAL • EASIER TO HANDLE • SUPERIOR RESULTS

The use of Ferri-Floc in water supplies has several advantages over other coagulants now in use. Economy of operation is a great factor in the minds of prospective users, but, once used Ferri-Floc immediately shows its ability to produce a higher quality of water at a lower cost.

ADVANTAGES OF FERRI-FLOC

1. *Coagulation is effective over a much wider pH range than with alum. Color flocs may be formed in the very acid range, where alum may not be employed. On the other hand, true hydrated ferric oxide flocs may be formed at pH 9-10, or even higher for the removal of turbidity and manganese.*
2. *The time required for floc formation, conditioning, and settling is in many cases considerably shorter than that required for other coagulants.*
3. *Filter runs have been markedly increased in several cases.*
4. *Manganese is successfully removed at pH values above 9.*
5. *Effluents may be produced which are exceedingly low in both iron and aluminum.*
6. *Hydrogen sulfide is removed, and taste and odor improved.*
7. *Ferric floc does not seem to stick to sand grains to form mud balls, and is subject to less "breaking through" on the filters.*

FREE BOOKLET

Send card or letter for free booklet on the advantages of Ferri-Floc to Tennessee Corporation, Grant Building, Atlanta, Georgia or Lockland, Ohio.

TENNESSEE CORPORATION
Atlanta, Georgia Lockland, Ohio

WORTHINGTON-GAMON

WATCH DOG WATER METERS

The meter used by thousands of municipalities in the U. S.

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER CO.

296 South Street, Newark 5, New Jersey

SUBSIDIARY OF

WORTHINGTON

WORTHINGTON PUMP AND MACHINERY CORPORATION

(Continued from page 6)

The crowning blow in the Truman administration's alleged persecution of our Navy came in the President's budget message last month. Taking official note of the serious water shortages plaguing various areas of the country, the Commander-in-Chief made a recommendation that threatens the very foundations of our wave warriors in asking Congress to "enact legislation authorizing the initiation of research to find means for transforming salt water into fresh water in large volume at economical costs." Did he think the Navy wouldn't find out that, at our present rate of water consumption in this country, they'd soon be hard put to float a battleship? [Page proof P.S.: Ye gods, the *Missouri*!]

Seriously, though, this and the President's action earlier in the month in setting up the Water Resources Policy Commission to make a review and reappraisal of those water resources programs having "a major immediate effect on the well being and proper functioning of the nation's economy" are welcome indications that the new public consciousness and appreciation of water supply problems may bear lasting fruit. Even if this action forebodes another political states rights squabble, we have almost everything to gain by an increased concern with the development, implementation and conservation of our water resources.

Besides, think of the extra tonnage the Navy will get when the ocean bottoms are uncovered.

But speaking of our National Military Establishment, with a bow to the Budget as well, we are happy to note that an economy-minded Air Force has finally decided to drop its exhaustive investigation of those flying saucers which whizzed through the imaginations of some of our most respected citizens a while back. Official conclusion, after a two-year survey of some 375 different hallucinations: They were the result of "(1) misinterpretation of various conventional objects, (2) a mild form of mass hysteria or (3) hoaxes." New York *Times* comment: "Somebody in his cups!" Our own advice to the crockery-crocked: "Drink water."

(Continued on page 10)

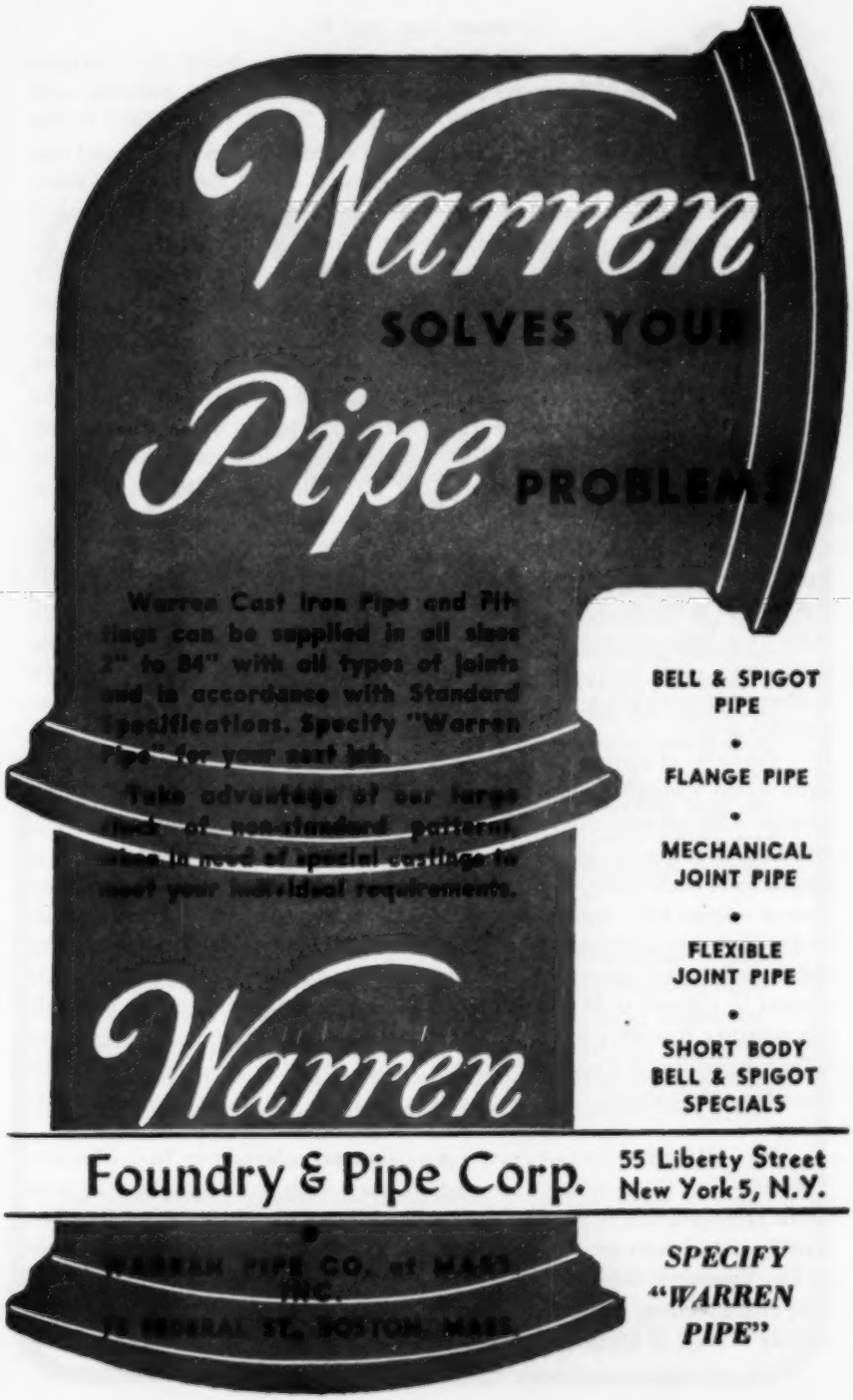
Cathodic PROTECTION is More Than Equipment

You can purchase good cathodic protection *equipment* from many reputable manufacturers of anodes, rectifiers, etc. But that's only half the answer to rust and corrosion problems. The rest of it is technical skill in the *application* of cathodic protection equipment and theory.

Electro Rust-Proofing has, at your disposal, a trained staff of corrosion specialists ready to give each problem the individual attention required for successful solution. Why not write today? There's no obligation.

ELECTRO RUST-PROOFING CORP., (N. J.)
BELLEVILLE 9, NEW JERSEY
REPRESENTED IN PRINCIPAL CITIES

E-11


Warren
SOLVES YOUR
Pipe PROBLEMS
Warren Cast Iron Pipe and Fittings can be supplied in all sizes 2" to 84" with all types of joints and in accordance with Standard specifications. Specify "Warren Pipe" for your next job.
Take advantage of our large stock of non-standard patterns, also in need of special castings to meet your individual requirements.
Warren
BELL & SPIGOT PIPE
•
FLANGE PIPE
•
MECHANICAL JOINT PIPE
•
FLEXIBLE JOINT PIPE
•
SHORT BODY BELL & SPIGOT SPECIALS
Foundry & Pipe Corp.
55 Liberty Street
New York 5, N.Y.
•
SPECIFY "WARREN PIPE"

(Continued from page 8)

Science Week in New York City, proclaimed to honor the American Association for the Advancement of Science and timed to coincide with the AAAS meeting in the Big City, December 26–31, found some 10,000 scientists examining our present progress in scientific achievement and taking some bold looks into our atomic future. Yet out of this "largest scientific convention embracing all science ever held," out of all its astronomical, physical, chemical, medical, psychological, geological, anthropological, abstrusical polysyllablism, the main point—at least to judge from its newspaper coverage—appeared to be the fact, announced by Dr. Vaden W. Miles of Wayne University, that a great many of the old saws by which our ancestors foretold their weather are scientifically accurate. In both feature article and editorial, our impressed press has spread wide the word that, of 333 pet proverbs, some 153 were correlated to conditions actually affecting weather, and that of 127 to which "principles" could be assigned, 68.5 per cent were true. So what if our groundhog and some of his furry and feathered friends were ruled out, so what if some of the more imaginative maxims ("When the moon lies on her back, she sucks the wet into her lap.") were at least partially exploded—what we want to know is how all this ties in with the "advancement" of science. If our forefathers on the basis of a little shrewd observation could issue reasonably accurate forecasts—and even make them rhyme—where, we may well ask, are our modern meteorologists, with all their elaborate instruments and formulas, advancing to?

There is, of course, the remote possibility that other reporters than we have found Einstein's new relativity a little thick, have had a wee bit of trouble with quanta, can't quite make the change from comics to cosmics and are even uneasy about the atom. Ascribing the undoubted error of emphasis to such isodopes as these, we can yet be happy that even the supermen of science find weather worth talking about. And if, on this basis, we reclassify them as human, they'll understand why a review of tried and true old saws attracted more attention than such an announcement as that of Dr. Robert C. Colwell of West Virginia Univ., who outlined a system for making weather forecasts with 95 per cent accuracy by noting the rising and falling intensity of radio reception. In an "Age of Science," we're still less than adolescents.

Re: Weather, though, we can no longer enforce our ban (January 1949 P&R, p. 4) on news of the custom-made variety. Not when the New York *Herald-Tribune* can seriously editorialize a plea to try dry-icing New York's water shortage out of existence. Not when so respected a scientist as Dr. Vincent J. Schaefer of General Electric's research laboratories insists that cloud seeding is a proved success. After all our self-enforced ban was merely a way of curbing our own enthusiasm, and now that others have

(Continued on page 12)

With Builders Chronoflo Electric Telemeter, the level of any reservoir or standpipe — no matter how remote, no matter what the weather — is shown at the central operating building. There's no need of travelling long distances to read meters and gauges at far-off installations.

The Chronoflo Telemeter, thoroughly proven in hundreds of plants, eliminates guesswork — provides complete indicating and recording information on flow, pressure, temperature, gate position, level, weight, etc. Operation is by a simple two-wire circuit over any distance from a few feet to many miles. For Bulletins and engineering information address Builders-Providence, Inc., (Division of Builders Iron Foundry), Prov. 1, R. I.

BUILDERS PRODUCTS

The Venturi Meter • Propelloflo and Orifice Meters • Kennison Nozzles • Venturi Filter Controllers and Gauges • Conveyoflo Meters • Type M and Flo-Watch Instruments • Wheeler Filter Bottoms • Master Controllers • Filter Operating Tables • Manometers • Chlorinizers — Chlorine Gas Feeders • Chronoflo Telemeters

BUILDERS PROVIDENCE
Instruments

(*Continued from page 10*)

caught up with us, we ought to let you know, at least, that silver iodide crystals, dispersed from simple smoke generators, have replaced dry ice as the preferred seed. Also, we ought to report the promising news that one Dr. Bernard Vonnegut has been working on a ground-bound method of seeding to replace the expensive airborne type. Using a $10 smoke generator, which can throw out a hundred million million particles per second—enough to seed a cubic mile of cloud at a cost of two or three tenths of a cent—Dr. Vonnegut figures that the crystals will be sucked up into the supercooled clouds with the smoke, providing nuclei around which snow crystals will form and later fall of their own weight. If "there is a new day coming," we wouldn't want it said that we didn't "help it on."

Out in the currently flooded Midwest, this will probably strain the quality of mercy, but in the Northeast and Southwest any straw is fair game for a clutch. Besides, we've always recommended parallel research on a technique of cloud dispersion to be applied when rain is neither necessary nor desirable.

George W. Moore, district sanitary engineer at Rochester, N.Y., has transferred to the home office of the State Health Dept. at Albany.

(*Continued on page 14*)

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25K

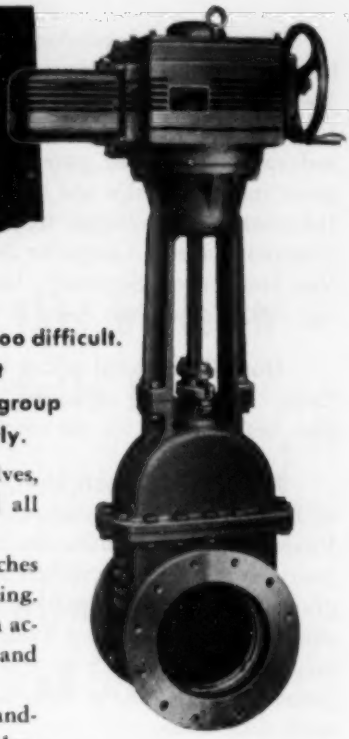
On Request

JOSEPH G. POLLARD CO., INC.

Pipe Line Equipment

New Hyde Park **New York**

You Need a KENNEDY Electrically Controlled Valve



Where manual operation is too lengthy or too difficult. Where valve control is desired at a distant point, or at two or more points. • Where a group of many valves must be operated frequently.

KENNEDY furnishes electrically controlled valves, for standard and low pressure services and all standard A.C. and D.C. voltages.

The motor, reduction gearing and limit switches are fully enclosed in a weather-proof housing. Safe, dependable operation is secured through accurately set limit switch with torque seating and thermal overload protection.

Emergency manual operation provided. Handwheel does not turn while valve is operated electrically.

KENNEDY electrically operated valves are ready for use. Setting of limit switch, trial operation and hydrostatic test are all completed at the factory.

KENNEDY Fig. 611G., Top-mounted Electrical Control on Standard, Iron Body, Double-Disc, Gate Valve; Services up to 125 Steam, 175 pounds Water, Oil or Gas; 4" through 60" sizes available.

Check List for Use with Inquiries or Orders

- ☐ Size of valve and whether O.S. & Y. or Non-rising Stem.
- ☐ Working or test pressure and actual unbalanced pressure on discs.
- ☐ Type connection; flanged, bell ends, or special.
- ☐ Position of valve in pipe line.
- ☐ Electric current characteristics; D. C. or A.C. voltage; phase, cycles if A.C.
- ☐ Number of control stations wanted.
- ☐ Brief description of installation; fluid or gas controlled, frequency of operation and function of valve.

Write for complete information. No obligation.

THE KENNEDY VALVE MFG. CO.
1033 EAST WATER ST.
ELMIRA, NEW YORK

VALVES • PIPE FITTINGS • FIRE HYDRANTS

OFFICE-WAREHOUSES IN NEW YORK, CHICAGO, SAN FRANCISCO • SALES REPRESENTATIVES IN PRINCIPAL CITIES

(Continued from page 12)

The Second Inter-American Sanitary Engineering Congress will be held at Mexico City, Mexico, March 16–26, under the sponsorship of the Mexican Section of the Inter-American Assn. of Sanitary Engineering, the Institute of Inter-American Affairs, the Pan American Sanitary Bureau and various Mexican governmental agencies. A balanced technical program, inspection trips and exhibits of manufacturers' products are planned. Information is available from the Conference Chairman, Alberto Ortiz Irigoyen, Calle de Campeche 244, Mexico, D.F., Mexico, or from Ralph J. Van Derwerker, Secretary, Inter-American Assn. of Sanitary Engineering, 2001 Connecticut Ave., N.W., Washington 8, D.C.

Dorr Co. general offices have been moved to Barry Place, Stamford, Conn. The former offices in New York will be retained as Eastern Sales Div. headquarters for the convenience of clients and friends.

Herbert M. Bosch, chief of the Minnesota health department's Section of Environmental Sanitation, has been appointed chief of the Section of Environmental Sanitation for the World Health Organization, with headquarters at Geneva, Switzerland. His activities involve directing programs for the international control of the major pandemic diseases through elimination of insanitary living conditions. Except for a period of military service, for which he was recently decorated by Queen Juliana (see January 1949 P&R, p. 10), Bosch has been with the Minnesota department since 1936.

Wendell R. LaDue has received an industrial forestry award from the Ohio Forestry Assn. for his work in planting Akron's watershed areas in trees.

W. W. DeBerard, Chicago city engineer since 1941, has been awarded Honorary Membership in the American Society of Civil Engineers. He had received a like honor from A.W.W.A. in 1942.

(Continued on page 16)

BOND-O

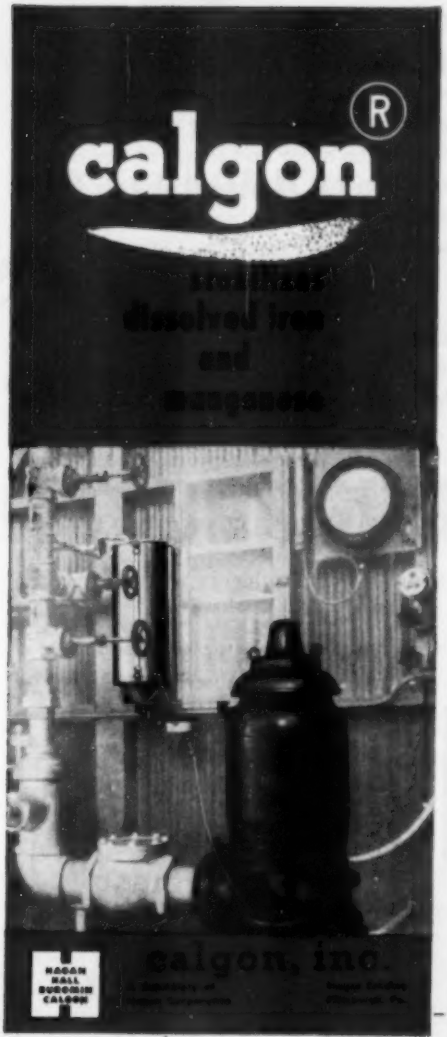
A safe and dependable self-caulking, self-sealing compound for jointing water mains. Used with complete confidence by hundreds of water works.

BOND-O is machine-blended for absolute uniformity and contains a germicide to inhibit oxidation by sulfur bacteria. BOND-O Rubber Packing Gaskets are resilient—bacteria-free and quickest of all packings to install. Made in sizes 4" to 60".

Northrop

NORTHROP & COMPANY, INC.
SPRING VALLEY, N. Y.

• Every Bond-o Joint is a Good Joint •



this bulletin tells how CALGON* eliminates red or black water

To get your copy, just fill in and mail the coupon.

*T.M. Reg. U.S. Pat. Off.

CALGON, INC. Hagan Building Pittsburgh 30, Pa.

Please send me your bulletin, "Calgon Stabilizes Dissolved Iron and Manganese."

NAME .....

POSITION .....

COMPANY .....

STREET AND NUMBER .....

CITY ..... ZONE ..... STATE .....

J-2

(Continued from page 14)

Three 10,390-ft. high fire hydrants, spaced some 150 ft. apart, were recently discovered by one of P&R's anonymi in the back country of southern Utah. Not provided for extinguishing fires in passing aircraft, either, these hydrants were for the protection of the office and home of the mountain ranger in charge of Cedar Breaks National Monument and the Union Pacific Railroad Hotel across the road. And if you object to the skyscraping image, you ought to go *up* and see them some time.

And while we're out in that part of the country, we find it interesting to note that production of oil from the oil shales of Colorado, Utah and Wyoming will be limited, not by the magnitude of the reserves, but by the water available in the area for plant and community use. That information, straight from W. C. Schroeder, chief of the Office of Synthetic Fuels in the Bureau of Mines, ought to give you a little perspective. Like our friend who deflated a soapster by pointing out that "Duz" does nothing without water, perhaps you can pour some water on troublesome oil men.

The New Jersey Society of Professional Engineers will meet at the Essex House, Newark, on April 14 and 15.

(Continued on page 18)

How to join *more* bell and spigot cast iron water mains *per hour* ...*at less cost*

ELIMINATE USE OF HIGH PRICED LEAD

Haymanite JOINTING COMPOUND

Each lb. of Haymanite equals 4 lbs. of lead . . reduces time, fuel and handling . . . eliminates caulking and large bell holes . . . simple to apply . . . self-sealing when broken.

Immediate deliveries. Free catalog

Producers also of M. H. Brand Caulking Lead

MICHAEL HAYMAN & CO.,
INCORPORATED
ESTABLISHED 1869

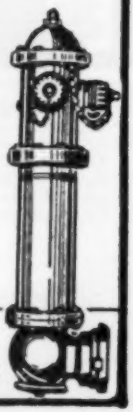
862 East Ferry St. Buffalo 11, N.Y.

"My Dad Was a Fireman"

"I'm the second generation of fire fighters, and I know what Dad knew fifty years ago, Kupferle Hydrants always work, and for me that's tops."

Send for specification sheets of the Kupferle line of Fire Hydrants.

JOHN C. KUPFERLE FOUNDRY CO.
ST. LOUIS



KUPFERLE FIRE HYDRANTS

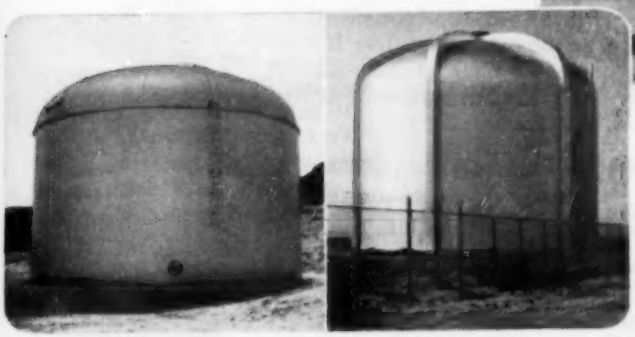
FOR ECONOMICAL

Water Storage

AT NATURAL ELEVATIONS

PITTSBURGH·DES MOINES

Standpipes and Reservoirs



Sound, enduring performance, based on correct engineering, dependable fabrication and careful erection, assures complete satisfaction with Pittsburgh-Des Moines Steel Standpipes and Reservoirs.

Over the years, their first-cost economy, low maintenance, and continued freedom from deterioration make these units an ideal water storage investment. *Write!*

PITTSBURGH·DES MOINES STEEL CO.

Plants at PITTSBURGH, DES MOINES and SANTA CLARA

Sales Offices at:

PITTSBURGH 3424 Neville Island | DES MOINES 825 Tuttle Street
NEW YORK Room 921, 270 Broadway | DALLAS 1229 Praetorian Bldg.
CHICAGO 1228 First Nat'l Bank Bldg. | SEATTLE 932 Lane Street
SANTA CLARA, CAL. 631 Alviso Road

(Continued from page 16)

H. A. Wons has been appointed manager of the Klenzade California Co. at Whittier, Calif.

Blood is thicker than water, they say, but water, too, apparently runs in the family. At least, a spot check of our membership rolls has turned up an even dozen father and son combinations and, undoubtedly, we've passed up many times that number for lack of knowledge. Not to prove any obscure point, but to introduce you—and ourself—to some of A.W.W.A.'s families of members, we herewith note the knowns and ask your help in completing the list:

Father	FAMILY	Son
A. P., Prof. of Chemistry, Univ. of Florida, Gainesville, Fla. (Apr. '29) *	**Black**	**Charles A.,** Pres., Black Labs., Inc., Gainesville, Fla. (Jan. '46)
William H., Civ. Engr., Philadelphia, Pa. (Apr. '09)	**Boardman**	**William H., Jr.,** Civ., Hydr. & San. Engr., Philadelphia, Pa. (Oct. '49)
Marvin R., Pres., Boyce Co., Inc., Clearwater, Fla. (Oct. '46)	**Boyce**	**Marvin R., Jr.,** Vice-Pres., Boyce Co., Inc., Clearwater, Fla. (Jan. '49)
Ray, Supt. & Chemist, Water Works, Milford, Ohio (Apr. '39)	**Erion**	**Daniel Ray, Jr.,** Water Works, Milford, Ohio (Apr. '40)
A. Anton, Sr., Phoenix, Ariz. (July '47)	**Frederickson** *	**Anton, Jr.,** Pres. & Gen. Mgr., City Utilities Co., Pima, Ariz. (Oct. '49)
David B., Pres., Lyon Chemicals, Inc., St. Paul, Minn. (Oct. '35)	**Morris**	**David B., Jr.,** Salesman, Lyon Chemicals, Inc., St. Paul, Minn. (Jan. '50)
Howard Scott, Vice-Pres. & Mgr., Indianapolis Water Co., Indianapolis, Ind. (Sept. '25)	**Morse**	**Daniel P.,** Development Engr., Indianapolis Water Co., Indianapolis, Ind. (Jan. '47)
Malcolm, Partner, Malcolm Pirnie Engrs., New York, N.Y. (May '17)	**Pirnie**	**Malcolm, Jr.,** Assoc. Engr., Malcolm Pirnie Engrs., New York, N.Y. (Oct. '39)
Willard F., Chairman of the Board, Rockwell Mfg. Co., Pittsburgh, Pa. (Feb. '28)	**Rockwell**	**Willard F., Jr.,** Pres., Rockwell Mfg. Co., Pittsburgh, Pa. (Jan. '44)
Caleb Mills, Cons. Engr., Metropolitan Dist. Water Bureau, Hartford, Conn. (Mar. '16)	**Saville**	**Thorndike,** Dean, College of Eng., New York Univ., New York, N.Y. (Aug. '20)
M. J., Sales Repr., Neptune Meter Co., Richmond, Va. (July '41)	**Siebert**	**Harry J.,** Sales Engr., Neptune Meter Co., Charlotte, N.C. (July '45)
John G., Sr., Southern Sales Mgr., Badger Meter Mfg. Co., Savannah, Ga. (Apr. '45)	**Valentino**	**Jack,** Sales Engr., Badger Meter Mfg. Co., Florence, Ala. (July '48)

* And a **Daughter,** too, **Miss Margaret,** Asst. Mgr., Secy. & Treas., City Utilities Co., Pima, Ariz.

Many are the reasons why Smith hydrants are used by America's leading cities!

Empire State Bldg., N. Y.

George Washington Bridge, N. Y.

Capitol Building, Wash., D. C.

Independence Hall, Phila.

New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

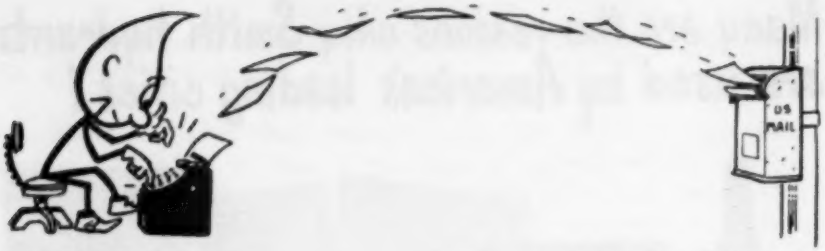
1. Working parts easily removed from top.
2. Frangible couplings for collision protection.
3. Maximum flow due to large stand pipe areas.
4. Tapered, frost-proof barrel
5. Compression-type valve.
6. Positive action drain—always closed when main valve is open.

31

THE A. P. SMITH MFG. CO.

ESTABLISHED 1874

EAST ORANGE, NEW JERSEY



Iloilo Also Athirst

To the Editor:

New York City isn't alone in its water shortage. Here in the Philippines we have one the year around. At Iloilo, the schedule goes like this:

Water between 7 A.M. and 8 A.M.

None between 8 A.M. and noon.

Then water from noon until 1:30 P.M.

No water from 1:30 P.M. to 4:30 P.M.

Water from 4:30 P.M. to 6 P.M.

Bathlessness from 6 P.M. to 7 A.M.

The letter on water saving received by Franklin Thomas ["Don't Be a Fourflusher," Nov. P&R, p. 2] should be reproduced and sent to every water user by each and every water works superintendent—*people should be made water conscious* in good times as well as bad.

Incidentally, I'll bet the fishing is good in Kensico and Rye lakes.

WM. MACPHERSON

Ledesma Hotel
Iloilo City, P.I.; Dec. 23, 1949

Having placed ourselves in Mr. MacPherson's dry boots and having read clippings he enclosed in his letter from the Iloilo City newspaper explaining the need for reducing pressure and from the Manila Philippines Free Press *rounding up stories of fights about, deaths from and costs of carted water, we're willing to consider ourselves lucky to be worried over what would seem to Iloiloans to be a wealth of water. As a matter of fact with the continuance of New York's plight, we, too, are begining to attach greater and greater value to the idea of a "Fourflusher" campaign and are pleased to note that Commissioner Carney in New York and various other water officials throughout the shortage area have been pushing the idea. As for the fishing—at Kensico, at least, the "big ones" are growing legs with which, traditionally, "to get away."*—ED.

Content and Discontent

To the Editor:

Although maybe it is a little too late to talk about JOURNAL cover, I'd like to express my opinion on this much debated point.

I go for the main contents listed on the cover which means real advantage for locating papers, especially for readers like me who have no yearly bound numbers.

I agree one hundred per cent with Mr. Rossum (October issue, p. 42) on returning to the publication of the complete old abstracts rather than the new too much condensed "Condensation."

This is especially valuable for readers outside the United States because it is very hard to get publications and technical literature. Therefore, the better the abstracts, the better the use we get from them.

ROBERTO ESPINOSA

Apdo. Aereo 4583
Bogota, Colombia; Jan. 9, 1950

To the Editor:

I regret that the abstracts have been eliminated from the JOURNAL. It has

(Continued on page 22)

all this and radio too,

helps NATIONAL clean water mains faster, better and more economically

The highly specialized equipment employed by the National Water Main Cleaning Co. today includes: walkie-talkie radio systems for maintaining constant communication between the point of operation and control valves or pumping stations, magnetic locators for tracing underground pipe, truck-mounted pumps for dewatering, trailer-mounted booster pumps for stepping-up pressure, pipe cutting machines and a tremendous variety of cleaning heads developed to meet the requirements of varying pipe sizes, conditions and layouts.

Even more important than adequate equipment is the experience necessary to cope with all conditions and situations. The nature of the obstruction, varying pipe sizes, unusual pipe layouts, the character of the water — all make each cleaning assignment an individual problem, calling for specialized experience, skill and equipment.

We'll be glad to check the condition of your water mains, recommend the required treatment and estimate the cost of National Water Main Cleaning service. Write today.

NATIONAL WATER MAIN CLEANING COMPANY

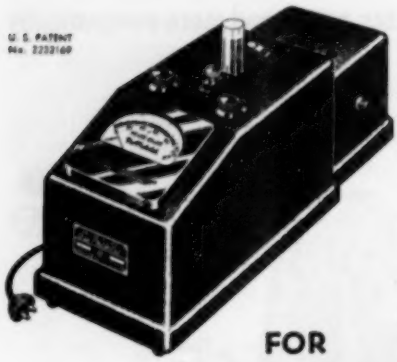
50 Church Street, New York 7, N. Y.

28

ATLANTA, GA., 1223 Mortgage Guarantee Bldg. & P. O. Box 8—Station E ● BOSTON, 115 Peterboro St. ● CHICAGO, Room 1336, S. Michigan Ave. ● KANSAS CITY, MO., 406 Merchandise Mart, 2201 Grand Ave. ● LOS ANGELES, 448 S. Hill Street ● LITTLE FALLS, N. J., Box 91 ● OMAHA, 3812 Castellar Street ● RICHMOND, 210 East Franklin Street ● SPRINGFIELD, MO., 1301 Prospect Ave. ● SALT LAKE CITY, 149–151 W. Second So. St. ● SAN FRANCISCO, 681 Market St. ● SIGNAL MT., TENN., 204 Slayton Street ● FLANDREAU, S. D., 315 No. Crescent St. ● MONTREAL, 2028 Union Ave. ● VANCOUVER, B. C., 505 West 1st Avenue ● WACO, P. O. Box 887 ● WINNIPEG, 576 Wall St. ● HAVANA ● SAN JUAN, PUERTO RICO ● BOGOTA ● CARACAS ● MEXICO CITY.

Hellige-Diller

PHOTOELECTRIC COLORIMETER



FOR WATER ANALYSIS

This Hellige-made Colorimeter has proved its dependability in more than a thousand installations. Equipped with seven light filters, a sensitive photoelectric cell, and microammeter, the colorimeter has the utmost differential response and is ideal for water analyses. Extremely simple in operation, determinations can be made accurately and rapidly with this instrument.

WRITE FOR CATALOG No. 500

HELLIGE
INCORPORATED
3718 NORTHERN BLVD.
LONG ISLAND CITY 1, N.Y.
HEADQUARTERS FOR COLORIMETRIC APPARATUS

(Continued from page 20)

lost 95% of its value and now seems like some mfg. house organ. Why can't the abstracts be again published?

The chief benefit of the JOURNAL was that it kept you in touch with all that was going on about water. This is not true now.

C. M. BARDWELL
2201 Fairfax St.
Denver, Colo.; Dec. 28, 1949

The contents will have been noted by Mr. Espinosa by the time his letter appears. Meanwhile, to Mr. Bardwell, we must invoke the old saw about "a rose by any other name . . . ," for under the heading "Condensation," we did publish 85 pages of abstracts during 1949. Agreeing with both that that does represent a curtailment—from 148, 146 and 123, in the three preceding years—we have to reiterate our own need for economy, the desire of many members to keep the abstracts clippable and our own desire to keep the technical and nontechnical contents of the Journal in balance. Last year's "Report of the Editor" (March 1949 issue, p. 279) presents the economic facts of life involved; but, certainly, if many members feel "that way" about the abstracts, we shall have to make some further provision for their expansion.—ED.

Filter Sand and Gravel

WELL WASHED AND CAREFULLY GRADED TO ANY SPECIFICATION.
PROMPT SHIPMENT IN BULK OR IN BAGS OF 100 LB. EACH.

Inquiries Solicited

Northern Gravel Co.
P. O. Box 307, Muscatine, Iowa

CLEARER WATER

obtained in **LESS SPACE** and at **LOWER COST** with this **GRAVER REACTIVATOR**

The accompanying photograph shows a Graver Reactivator installed alongside a conventional rectangular treating tank for the water supply of a West Coast municipality.

The two units have the same capacity — but notice the far smaller size of the circular GRAVER unit.

And this saving in space is only one of the GRAVER advantages. With initial raw water turbidity varying between 50 and 200 ppm, the smaller GRAVER unit produces an effluent with only 4.5 ppm turbidity . . . less than half that of the effluent from the larger conventional unit, and with no greater cost of chemicals.

The Engineer operating this equipment writes: *"You are to be congratulated on having a piece of equipment that really can live up to its expectations."*

To be sure of dependable results in treating your water supply, such as those obtained at this plant, investigate GRAVER Reactivators. Write for complete information. GRAVER recommendations are based on 40 years of specialized experience in solving Water Treatment problems.

GW 409

GRAVER

GRAVER WATER CONDITIONING CO.

216 West 14th Street, New York 11, New York, U.S.A.

CHICAGO • PHILADELPHIA • CLEVELAND

A DIVISION OF GRAVER TANK & MFG. CO. INC. EAST CHICAGO, IND.

Professional Services

ALBRIGHT & FRIEL, INC.

Consulting Engineers

Water, Sewage and Industrial Waste Problems
Airfields, Refuse Incinerators, Power Plants
Industrial Buildings
City Planning Reports Valuations
Laboratory

121 S. Broad St. **Philadelphia 7, Pa.**

CLINTON L. BOGERT ASSOCIATES

Consulting Engineers

CLINTON L. BOGERT — IVAN L. BOGERT
J. M. M. GREIG — ROBERT A. LINCOLN
DONALD M. DITMARS — ARTHUR P. ACKERMAN

Water and Sewage Works
Refuse Disposal — Industrial Wastes
Drainage — Flood Control

624 Madison Avenue **New York 22, N. Y.**

CHAS. B. BURDICK — LOUIS R. HOWSON
DONALD H. MAXWELL

ALVORD, BURDICK & HOWSON

Engineers

Water Works, Water Purification, Flood Relief, Sewerage, Sewage Disposal Drainage, Appraisals, Power Generation

Civic Opera Building **Chicago 6**

BOWE, ALBERTSON & ASSOCIATES

Engineers

Sewerage—Sewage Treatment
Water Supply—Purification
Refuse Disposal—Analyses
Valuations—Reports—Designs

110 Williams St. **New York 7, N.Y.**
2082 Kings Highway **Fairfield, Conn.**

CARL A. BAYS & ASSOCIATES

Geologists—Engineers—Geophysicists
Industrial Consultants

Office and Laboratory—308 N. Orchard St.
Mail Address—P.O. Box 189
Urbana, Illinois

BUCK, SEIFERT AND JOST

Consulting Engineers
(Formerly Nicholas S. Hill Associates)

WATER SUPPLY—SEWAGE DISPOSAL—
HYDRAULIC DEVELOPMENTS

Reports, Investigations, Valuations, Rates, Design, Construction, Operation, Management, Chemical and Biological Laboratories

112 E. 19th St., New York 3, N. Y.

A. S. BEHRMAN

Chemical Consultant

Water Treatment
Ion Exchange Processes and Materials
Patents

9 S. Clinton St. **Chicago 6, Ill.**

BURGESS & NIPLE

Consulting Engineers
(Established 1908)

Water supply, treatment and distribution
Sewage and industrial wastes disposal
Investigations, reports, appraisals, rates
Airports Municipal Engineering Supervision

584 E. Broad St. **Columbus 15, Ohio**

BLACK & VEATCH

Consulting Engineers

4706 Broadway, Kansas City 2, Mo.

Water Supply Purification and Distribution; Electric Lighting and Power Generation, Transmission and Distribution; Sewerage and Sewage Disposal; Valuations, Special Investigations and Reports

BURNS & McDONNELL ENGINEERING CO.

Consulting Engineers—51 Years

Water Works, Light and Power, Sewerage, Reports, Designs, Appraisals, Rate Investigations.

Box 7088 Country Club P.O., Kansas City 2, Mo.
Office: 95th & Troost Ave.

BLACK LABORATORIES, INC.

Consulting Engineers and Chemists

on all problems of
Water, Sewage and Waste Treatment
ANALYSIS—TREATMENT—
CONTROL—RESEARCH

968 S. Oak St. **Gainesville, Fla.**

JAMES M. CAIRD

Established 1898

C. E. CLIFTON, H. A. BENNETT

Chemist and Bacteriologist

WATER ANALYSIS
TESTS OF FILTER PLANTS

Cannon Bldg. **Troy, N. Y.**

CAMP, DRESSER & McKEE

Consulting Engineers

Water Works, Water Treatment,
Sewerage and Wastes Disposal,
Flood Control

Investigations, Reports, Design
Supervision, Research, Development

6 Beacon St. Boston 8, Mass.

GANNETT FLEMING CORDDRY & CARPENTER, Inc.

Engineers

Water Works—Sewerage
Industrial Wastes—Garbage Disposal
Roads—Airports—Bridges—Flood Control
Town Planning—Appraisals
Investigations & Reports

Harrisburg, Pa.
Scranton, Pa. Pittsburgh, Pa.

THE CHESTER ENGINEERS

Water Supply and Purification,
Sewerage Systems, Sewage and
Industrial Waste Treatment,
Power Development and Applications,
Investigations and Reports,
Valuations and Rates

210 E. Park Way at Sandusky
PITTSBURGH 12, PA.

GILBERT ASSOCIATES, INC.

Engineers and Consultants

Water Supply and Purification
Sewage and Industrial Waste Treatment
Chemical Laboratory Service
Investigations and Reports

New York Reading, Pa. Washington
Houston Philadelphia

CONSOER, TOWNSEND & ASSOCIATES

Water Supply—Sewerage
Flood Control & Drainage—Bridges
Ornamental Street Lighting—Paving
Light & Power Plants—Appraisals

351 E. Ohio St. Chicago 11

IVAN M. GLACE

Consulting Sanitary Engineer

Water Supply and Purification
Sewerage, Sewage and Industrial
Wastes Treatment
Design, Construction & Supervision of
Operation
Laboratory Service

1001 N. Front St. Harrisburg, Pa.

DE LEUW, CATHER & COMPANY

Water Supply Sewerage
Railroads Highways

Grade Separations—Bridges—Subways
Local Transportation

Investigations—Reports—Appraisals
Plans and Supervision of Construction

150 N. Wacker Drive Chicago 6
79 McAllister St. San Francisco 2

GREELEY & HANSEN

Engineers

Water Supply, Water Purification
Sewerage, Sewage Treatment
Flood Control, Drainage, Refuse Disposal

220 S. State Street, Chicago 4

FAY, SPOFFORD & THORNDIKE

Engineers

Charles E. Spofford — Ralph W. Horne
John Ayer — William L. Hyland
Bion A. Bowman — Frank L. Lincoln
Carroll A. Farwell — Howard J. Williams

Water Supply and Distribution—Drainage
Sewerage and Sewage Treatment—Airports

Investigations Reports Designs Valuations
Supervision of Construction

Boston New York

HAVENS & EMERSON

W. L. Havens C. A. Emerson
A. A. Burger F. C. Tolles F. W. Jones

Consulting Engineers

Water, Sewage, Garbage, Industrial
Wastes, Valuations—Laboratories

Leader Bldg. Cleveland 14
Woolworth Bldg. New York 7

O. S. FENT

Consulting Ground Water Geologist

Water Supply Surveys
Complete Test Drilling Service

Box 477 Salina, Kansas

CHARLES HAYDOCK

Consulting Engineer

Water Works and Sanitation Industrial Wastes
Design, Construction, Operation and Management
Reports and Valuations

2314 Girard Trust Co. Bldg.
Broad St. & S. Penn Square
Philadelphia 2

Professional Services

HITCHCOCK & ESTABROOK, INC.

Lester D. Lee, Associate

Consultants to Municipalities since 1920

Water, Sewerage, Paving, Power Plants,
Airports, Reports and Appraisals

521 Sexton Bldg., Minneapolis 15, Minn.

Roberto Meneses Hoyos & Co.

Ground Water Engineers

Water Supply — Geophysics
Test Drilling — Flow Tests
Explorations — Reports
Design, Valuations & Supervision

Reforma 12 — **Mexico City**

HORNER & SHIFRIN

Consulting Engineers

W. W. Horner — S. W. Jens
H. Shifrin — E. E. Bloss
V. C. Lischer

Water Supply—Airports—Hydraulic Engineering—Sewerage—Sewage Treatment—Municipal Engineering—Reports

Shell Building — **St. Louis 3, Mo.**

METCALF & EDDY

Engineers

Water, Sewage, Drainage, Refuse
and Industrial Wastes Problems
Airfields — Valuations
Laboratory

Statler Building, Boston 16 — **111 Sutter St., San Francisco 4**

ROBERT W. HUNT CO.

Inspection Engineers

(Established 1888)

Inspection and Test at Point
of Origin of Pumps, Tanks,
Conduit, Pipe and Accessories

175 W. Jackson Blvd.
Chicago 4, Ill.
and Principal Mfg. Centers

THE H. C. NUTTING COMPANY

Engineers

Water Distribution Studies
Water Waste Surveys
Trunk Main Surveys
Meter and Fire Flow Test

4120 Airport Road — **Cincinnati 26, Ohio**

JONES, HENRY & SCHOONMAKER

(Formerly Jones & Henry)

Consulting Sanitary Engineers

Water Works
Sewerage & Treatment
Waste Disposal

Security Bldg. — **Toledo 4, Ohio**

Parsons, Brinckerhoff, Hall & Macdonald

G. Gale Dixon, Associate

Engineers

Dams — Water Works — Sewerage
Airports — Bridges — Tunnels
Traffic & Transportation Reports — Highways
Subways — Foundations
Harbor Works — Valuations
Power Developments — Industrial Buildings

51 Broadway, New York 6, N.Y.

MORRIS KNOWLES, INC.

Engineers

Water Supply and Purification,
Sewerage and Sewage Disposal,
Industrial Wastes, Valuations,
Laboratory, City Planning.

Park Building — **Pittsburgh 22, Pa.**

MALCOLM PIRNIE ENGINEERS

Civil & Sanitary Engineers

Malcolm Pirnie — Ernest W. Whitlock
Richard Hazen — G. G. Werner, Jr.

Investigations, Reports, Plans
Supervision of Construction and Operations
Appraisals and Rates

25 W. 43rd St. — **New York 18, N. Y.**

R. M. LEGGETTE

Consulting Ground Water Geologist

Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports

551 Fifth Avenue — **New York 17, N. Y.**

THE PITOMETER COMPANY

Engineers

Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings

50 Church St. — **New York 7, N. Y.**

LEE T. PURCELL

Consulting Engineer

Water Supply & Purification: Sewerage & Sewage Disposal; Industrial Wastes; Swimming Pool Control; Investigations & Reports; Design; Supervision of Construction; Operation

Analytical Laboratories

1 Lee Place **Paterson 1, N. J.**

STANLEY ENGINEERING COMPANY

Waterworks—Sewerage
Drainage—Flood Control
Airports—Electric Power

Hershey Building
Muscatine, Ia.

THOMAS M. RIDDICK

Consulting Engineer and Chemist

Municipal and Industrial Water Purification, Sewage Treatment, Plant Supervision, Industrial Waste Treatment, Laboratories for Chemical and Bacteriological Analyses

369 E. 149th St. **New York 55, N.Y.**

ALDEN E. STILSON & ASSOCIATES

Limited

Consulting Engineers

Water Supply Sewerage Waste Disposal
Mechanical Structural

Surveys Reports Appraisals

209 South High St. **Columbus, Ohio**

RIPPLE & HOWE

Consulting Engineers

O. J. Ripple B. V. Howe

Appraisals—Reports
Design—Supervision

Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports

426 Cooper Bldg., Denver 2, Colo.

WARD & STRAND

Engineers

Water — Power
Sewerage — Drainage
Industrial Wastes — Industrial Building
Paving

1 W. Main St. **Madison 3, Wis.**

NICHOLAS A. ROSE

Consulting Ground Water Geologist

Investigations
Reports
Advisory Service

1309 Anita Ave. **Houston 4, Tex.**

WESTON & SAMPSON

Consulting Engineers

Water Supply and Purification; Sewerage, Sewage and Industrial Waste Treatment. Reports, Designs, Supervision of Construction and Operation; Valuations. Chemical and Bacteriological Analyses

14 Beacon Street **Boston 8, Mass.**

RUSSELL & AXON

Consulting Engineers

Geo. S. Russell F. E. Wenger
Joe Williamson, Jr.

Water Works, Sewerage, Sewage Disposal, Industrial and Power Plants, Appraisals

408 Olive St. **Municipal Airport**
St. Louis 2, Mo. **Daytona Beach, Fla.**

WHITMAN & HOWARD

Engineers

(Est. 1869.)

Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems

89 Broad St. **Boston, Mass.**

J. E. SIRRINE COMPANY

Engineers

Water Supply & Purification, Sewage & Industrial Waste Disposal, Stream Pollution Reports, Utilities, Analyses

Greenville **South Carolina**

WHITMAN, REQUARDT & ASSOCIATES

Engineers *Consultants*

Civil—Sanitary—Structural
Mechanical—Electrical
Reports, Plans,
Supervision, Appraisals

1304 St. Paul St. **Baltimore 2, Md.**

Membership Changes

NEW MEMBERS

Applications received December 1 to 31, 1949

Allen, J. James, Auditor & Asst. Secy., Long Island Water Corp., 733 Sunrise Highway, Lynbrook, N.Y. (Jan. '50) *M*

Allen, William F., Asst. Supt., Filtration Plant, Board of Public Affairs, Swanton, Ohio (Jan. '50) *MPR*

Bachler, Harry A., Pres., H. L. Bachler Co., 1216 Race St., Cincinnati 10, Ohio (Jan. '50) *MR*

Baxter, Wayne N., *see* Larned, City of

Beechwood, Christian Theodore, III, San. Engr., State Dept. of Health, Bureau of San. Eng., Harrisburg, Pa. (Jan. '50) *P*

Beltran Valenzuela, Miguel, Owner & Director, Ing. Miguel Beltran Valenzuela, Ayuntamiento No. 164, Mexico, D.F., Mexico (Jan. '50) *MPR*

Benson, Einar T., Gen. Sales Dept., Frigidaire Div., General Motors Corp., 300 Taylor St., Dayton 1, Ohio (Jan. '50) *R*

Bethlehem, Town of, Water Dist. No. 1, Claude Hotaling, Supt., 388 Kenwood Ave., Delmar, N.Y. (Munic. Sv. Sub. Jan. '50) *MPR*

Bishop, Fred W., Chief Chemist, Southland Paper Mills, Inc., Box 149, Lufkin, Tex. (Jan. '50) *PR*

Born, William P., Water Engr., Bureau of Water, Reading, Pa. (Jan. '50) *M*

Brown, William K., Partner-Mgr., Culligan Soft Water Service Co., E. 12th St., Worthington, Minn. (Jan. '50) *PR*

Buckner, Frank, Supt., Hans Reese Tannery, Asheville, N.C. (Jan. '50)

Buffle, Jean Ph., Engr.-Chemist & Microbiologist, Chief of Lab., Service des Eaux de Genève, Rue du Stand 12, Geneva, Switzerland (Jan. '50) *P*

Burnett, Carey C., City Engr., 1306 Slater St., Valdosta, Ga. (Jan. '50)

Call, Ralph B., City Mgr., City Bldg., Hoisington, Kan. (Jan. '50) *M*

Carpenter, Clarence Willard, Jr., Graduate Student, 507—15th Ave., S.E., Minneapolis, Minn. (Jr. M. Jan. '50)

Cassedy, Thomas S., Partner, Whitman, Requardt & Assoc., 1304 St. Paul St., Baltimore 2, Md. (Jan. '50)

Caton, John J., Salesman, Warren Foundry & Pipe Corp., 625A S. Main St., Phillipsburg, N.J. (Jan. '50)

Charlestown Water Works, R. W. Press, Supt., Charlestown, Ind. (Corp. M. Jan. '50)

Church, W. G., Supt., Munic. Water Works, City Hall, Dequeen, Ark. (Jan. '50)

Clayton, William Roland, Supt., Water & Light Dept., Thomasville, Ga. (Jan. '50) *M*

Cochran, Deale Binion, Sales Engr., Johns-Manville Corp., 101 Marietta St., Atlanta, Ga. (Jan. '50) *M*

Coensparger, C. C., Director, Water Dept., Hialeah, Fla. (Jan. '50) *M*

Davies, John, Works Supt., Eng. Dept., City Hall, 101 Main St., Penticton, B.C. (Jan. '50)

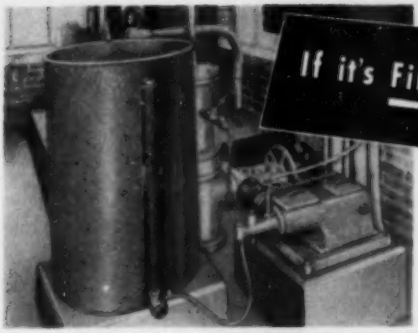
Diaz Quinones, Marino, Civ. Engr., Public Service, 74 & 17th St., Rpto. Playa, Miramar, Marianao, Cuba (Jan. '50)

Drew, Samuel Tilton, Project Engr., Rader Knappen Tippetts Eng. Co., 1615 du Pont Bldg., Miami, Fla. (Jan. '50) *MPR*

Estes, John M., III, Sunshine Foundry & Machine Co., Box 125, 22nd St. Station, St. Petersburg, Fla. (Jan. '50)

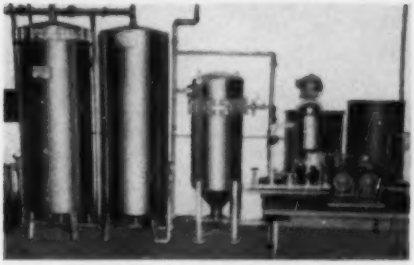
Fayetteville Water Plant, William C. Smith, Supt., Fayetteville, Ark. (Corp. M. Jan. '50) *MPR*

(*Continued on page 30*)

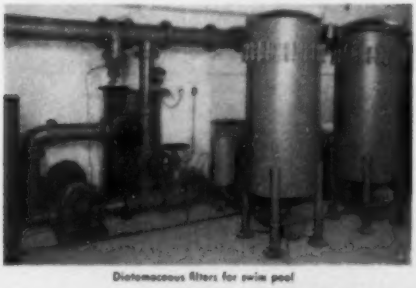


Fluoride treatment for prevention of tooth decay

Hypochlorinating flows ranging from 60 to 3600 GPM



Typical beverage plant water purification equipment



Diatomaceous filters for swim pool

If it's Filtering or Chemical Feeding

Ask

% PROPORTIONEERS %

about...

- CHLORINATION
- CHLORINE DIOXIDE TREATMENT
- CORROSION CONTROL
- COAGULATION
- FLUORIDATION
- SEWAGE TREATMENT
- pH CONTROL
- DIATOMACEOUS FILTERING

In communities of all sizes, from small town to giant city, %Proportioneers% has solved the problems of water purification and filtering. With experience gained from over 27,000 installations, %Proportioneers% knows the answers and can save you money. It pays to bring your water treating problems to us! Bulletins on request.

% PROPORTIONEERS, INC. %

61 CODDING STREET • PROVIDENCE 1, R. I.

(*Continued from page 28*)

Feighner, W. P., Gen. Mgr., Feighner Welding Works, Box 5, Fremont, Ohio (Jan. '50) *R*

Ferguson, G. C., *see* Waynesville, Town of

Fowler, Arthur B., Jr., Sales Engr., Wallace & Tiernan Co., Inc., 513 S. Tryon St., Charlotte, N.C. (Jan. '50) *P*

Frazier, Thomas H., The Opalco Lab., McKeesport, Pa. (Jan. '50) *MPR*

Frederickson, A., Jr., Pres. & Gen. Mgr., City Utilities Co., Pima, Ariz. (Oct. '49) *MP*

Frederickson, Margaret (Miss), Asst. Mgr. & Secy.-Treas., City Utilities Co., Pima, Ariz. (Oct. '49) *M*

Fulle, Henry, Water System, Valley Cottage, N.Y. (Jan. '50) *MPR*

Gaeke, Harry F., Engr., Dept. of Water, 101 W. 3rd St., Dayton 2, Ohio (Jan. '50) *M*

Gildea, R. E. L., *see* Virginia, Univ. of

Gonzalez Jiminez, Rafael Erasmo, Engr. of Public Works, Cienfuegos No. 159, Havana, Cuba (Jan. '50) *R*

Granstrom, Marvin L., Asst. Prof. of San. Eng., Univ. of North Carolina, Chapel Hill, N.C. (Jan. '50) *PR*

Grundler, Francis E., Engr., Alvord, Burdick & Howson, Box 622, Cedar Rapids, Iowa (Jan. '50)

Hale, Charles L., *see* Redkey Water Plant

Hansen, Robert, *see* Lowell Water Dist.

Harrison, Zadok Daniel, c/o Chiriqui Land Co., Puerto Armuelles, Republic of Panama (Oct. '49) *P*

Harsha, Edward Norris, Chief Engr., Kansas Inspection Bureau, 701 Jackson St., Topeka, Kan. (Jan. '50) *M*

Harvey, Joseph T., Vice-Pres., Lyon Chemicals, Inc., 2305 Hampden Ave., St. Paul 4, Minn. (Jan. '50)

Heilig, Harold J., Supervisor, Water Dept., Div. of Water Distr., 945 Ottawa St., Dayton, Ohio (Jan. '50) *M*

Hollopeter, R. R., Asst. City Engr., City Hall, Wooster, Ohio (Jan. '50) *M*

Hope Water & Light Plant, Clyde Zinn, Supt., Hope, Ark. (Corp. M. Jan. '50) *M*

Hoss, Walter B., Mgr., Water & Light Dept., Stillwater, Okla. (Jan. '50) *M*

Hotaling, Claude, *see* Bethlehem, Town of

Hurst, David Henry, City Engr., Tifton, Ga. (Jan. '50) *M*

Jackson, John Samuel, Mgr., Munic. Water & Sewer Works, Box 368, Waldo, Ark. (Jan. '50) *M*

Johnson, Walter K., 3552—16th Ave., S., Minneapolis 7, Minn. (Jr. M. Jan. '50)

Kass, Edwin A., Prin. Asst., Henry W. Taylor, Cons. Engr., 11 Park Pl., New York 7, N.Y. (Jan. '50) *P*

Kawata, Kazuyoshi, Graduate Student, San. Eng., Univ. of Minnesota, Minneapolis, Minn. (Jr. M. Jan. '50)

Keyser, Arthur M., Supt., Bremen Light & Water Co., Bremen, Ind. (Jan. '50)

Kneisley, Harry S., Supt., Div. of Water Supply, 309 Municipal Bldg., Dayton, Ohio (Jan. '50) *MR*

Kratzer, Harvey C., Chief Engr., Pumping Station, Northampton Borough Munic. Authority, R.R. 1, Coplay, Pa. (Jan. '50)

Larned, City of, Wayne N. Baxter, City Mgr., Water Dept., Larned, Kan. (Corp. M. Jan. '50)

Leclercq, Emile P., San. Engr., Gibbs & Hill, Inc., Pennsylvania Station, New York 1, N.Y. (Jan. '50)

Leeper, Hiram B., Supervisor, Main Constr., Dept. of Water, 945 Ottawa St., Dayton, Ohio (Jan. '50) *M*

Lowell Water Dist., Robert Hansen, Comr., Lowell, Wash. (Corp. M. Jan. '50) *M*

Macdonald, Robert A., Supt. of Water Revenue, Corp. of City of Toronto, 103 City Hall, Toronto 1, Ont. (Jan. '50)

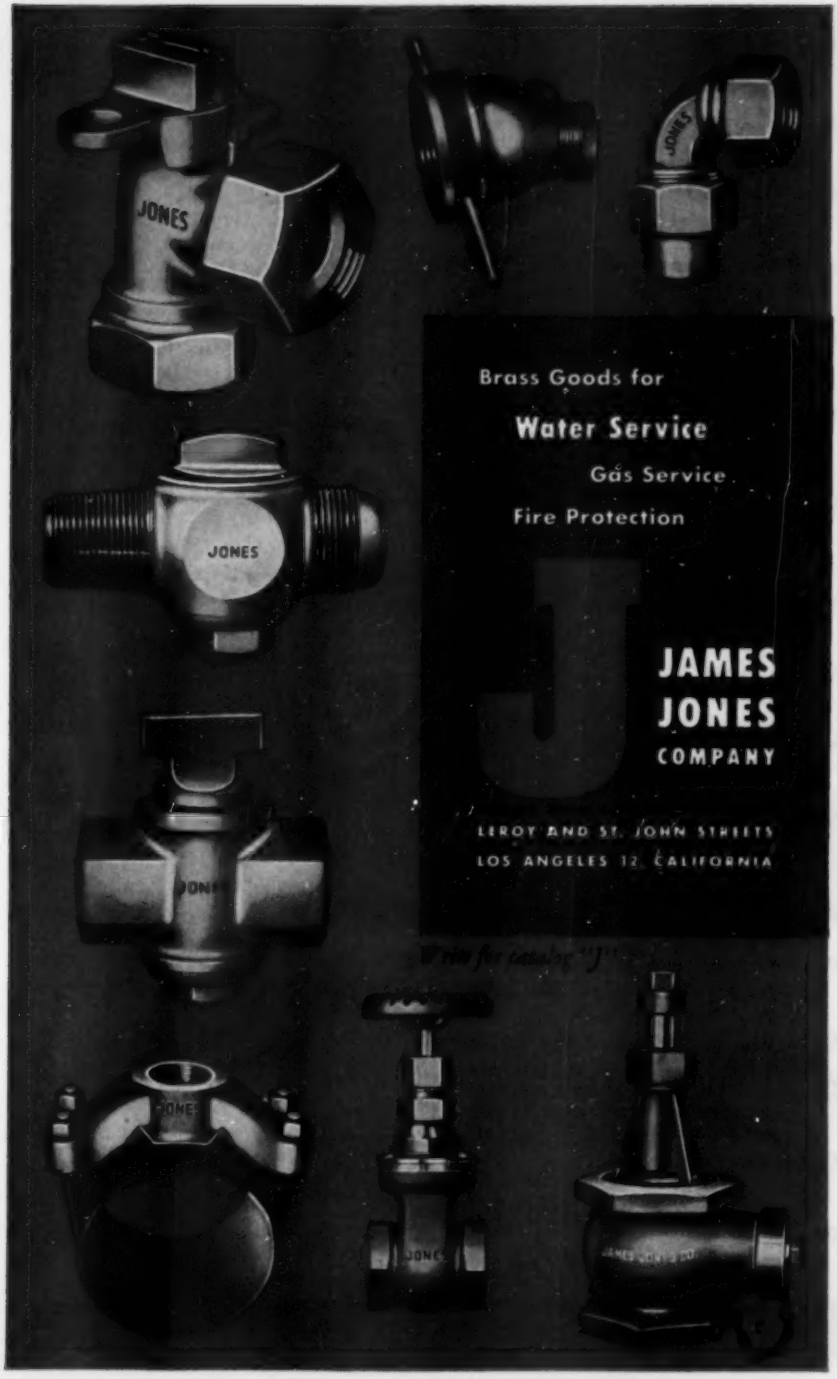
Matthews, Albert Gordon, Chief Engr., Water Survey & Research Div., Tallahassee, Fla. (Jan. '50) *R*

McAlister, G. M., Foreman, Water Works, 646 Hemphill Ave., N.W., Atlanta, Ga. (Jan. '50)

McDonnell, George H., Chief Engr., Tighe & Bond, 189 High St., Holyoke, Mass. (Jan. '50) *P*

McHugh, Lynne, Supt., Central Water Works, Tennessee Coal, Iron & R.R. Co., Route 14, Box 552, Birmingham 8, Ala. (Jan. '50)

(*Continued on page 32*)


JONES
JONES
JONES
JONES
Brass Goods for
Water Service
Gas Service
Fire Protection
JAMES
JONES
COMPANY
LEROY AND ST. JOHN STREETS
LOS ANGELES 12, CALIFORNIA
Write for catalog "J"

(*Continued from page 30*)

McWherter, Biggs, Gen. Supt., Eloy Water & Elec. Co., Eloy, Ariz. (Oct. '49) *M*

Melick, Richard F., Operator, Div. of Water, 375 E. Jeffrey Pl., Columbus 2, Ohio (Jan. '50)

Menke Stone & Lime Co., E. H. Siebrasse, Secy.-Treas., 828 Vermont St., Quincy, Ill. (Assoc. M. Jan. '50)

Middleton, Francis C., Director, Public Utility, City Hall, Clearwater, Fla. (Jan. '50) *MPR*

Miller, Victor E., Supt. of Distr., Consumers Water Co., Coral Gables, Fla. (Oct. '49) *MPR*

Miller, Wallace T., Mgr., Rochester & Lake Ontario Water Service Corp., Triangle Bldg., Rochester, N.Y. (Jan. '50) *Director '47–'50. MP*

Missouri Div. of Health, L. E. Ordelheide, Director, Bureau of Public Health Eng., Jefferson City, Mo. (Corp. M. Jan. '50) *MPR*

Moeller, Carl F., Chief Engr., Indiana State Farm, Box 76, Greencastle, Ind. (Jan. '50)

Morris, David B., Jr., Salesman, Lyon Chemicals, Inc., 2305 Hampden Ave., St. Paul 4, Minn. (Jan. '50)

Naples Water Dept., W. F. Savidge, Supt., Naples, Fla. (Corp. M. Jan. '50) *MP*

Nyack Board of Water Comrs., E. F. Perry Jr., Chairman, 134 Main St., Nyack, N.Y. (Munic. Sv. Sub. Jan. '50) *MP*

Ordelheide, L. E., *see* Missouri Div. of Health

Patterson, Richard Nolen, Salesman, Johns-Manville Corp., Box 1211, Tampa, Fla. (Jan. '50) *M*

Perry, E. F., Jr., *see* Nyack Board of Water Comrs.

Perry, John S., Sales Engr., Wallace & Tiernan Co., Inc., 415 Brainard, Detroit 1, Mich. (Jan. '50) *PR*

Peterson, Thoburn F., Supt., Water Works, City Bldg., Middletown, Ohio (Jan. '50)

Pinney, R. G., Owner, R. G. Pinney Constr., Box 135, Beachville, Ont. (Jan. '50)

Press, R. W., *see* Charlestown Water Works

Priestley, James N., Asst. Supt., Water Dept., City Hall, Jackson, Tenn. (Jan. '50)

Proctor, Bob Lee, Chemist, Central Power & Light Co., Box 2121, Corpus Christi, Tex. (Jr. M. Jan. '50) *MP*

Ratcliffe, Richard G., Salesman, James B. Clow & Sons, 1420 Doten Ave., Columbus 12, Ohio (Jan. '50)

Redkey Water Plant, Charles L. Hale, Supt., Water Works, City Bldg., Redkey, Ind. (Corp. M. Jan. '50) *M*

Roney, Johnson, II, Mfrs. Repr., 608 Oak Ave., Clearwater, Fla. (Jan. '50)

Ruchhoft, Clarence C., San. Engr. Director, Environmental Health Center, U.S. Public Health Service, 1014 Broadway, Cincinnati 8, Ohio (Jan. '50) *P*

Russell, Charles L., Asst. Supt., Dept. of Water Works, 532 Franklin St., Michigan City, Ind. (Jan. '50) *M*

Savidge, W. F., *see* Naples Water Dept.

Siebrasse, E. H., *see* Menke Stone & Lime Co.

Simmons, G. M., Clerk, Brevard County Water Control, Titusville, Fla. (Jan. '50)

Slater, John P., San. Engr., Eng. Div., State Dept. of Conservation, 425 Steely St., West Lafayette, Ind. (Jan. '50) *MP*

Smith, Bernard George, Chief Control Chemist, Hiram Walker & Sons, Inc., Peoria 1, Ill. (Jan. '50) *P*

Smith, William C., *see* Fayetteville Water Plant

Stinz, Stephen U., Asst. Supervisor, Dept. of Water, 22 E. Fairview Ave., Dayton 5, Ohio (Jan. '50)

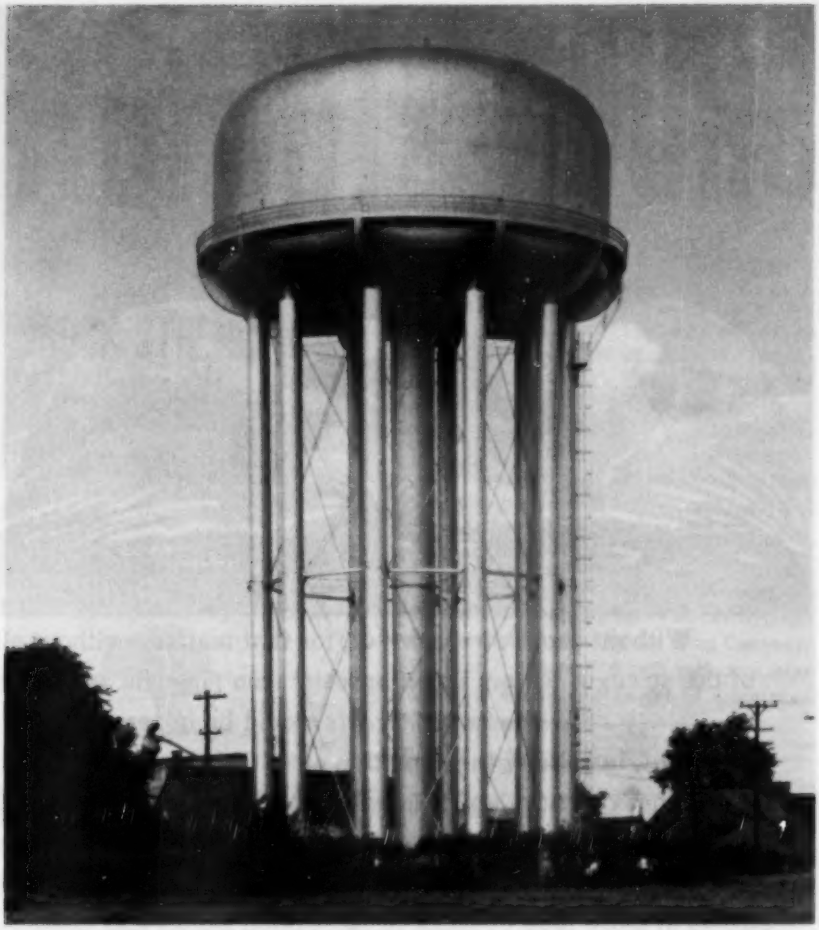
Tibbetts, Frank W., Chief Chemist, Reading R.R. Co., Test Dept., N. 6th St., Reading, Pa. (Jan. '50) *P*

Titterton, George Edwin, Sales Engr., Wallace & Tiernan Co., Inc., 230 E. Ohio, Indianapolis, Ind. (Jan. '50) *P*

Virginia, Univ. of, R. E. L. Gildea, Assoc. Prof. of Civ. Eng., Dept. of Eng., Thornton Hall, Charlottesville, Va. (Corp. M. Jan. '50) *MPR*

Waynesville, Town of, G. C. Ferguson, Town Mgr., Waynesville, N.C. (Corp. M. Jan. '50)

(*Continued on page 36*)



Horton Radial-Cone Elevated Tank

This 1,000,000-gal. radial-cone bottom elevated water tank has been installed in the Frederick, Md., water distribution system to improve water service. The tank is 105 ft. to the bottom and has a range in head of 35 ft.

Write our nearest office for estimates on radial-cone or ellipsoidal-bottom elevated water tanks when planning waterworks improvements.

CHICAGO BRIDGE & IRON COMPANY

BIRMINGHAM CHICAGO TULSA BOSTON SALT LAKE CITY
PHILADELPHIA NEW YORK DETROIT SEATTLE CLEVELAND
SAN FRANCISCO HOUSTON ATLANTA HAVANA LOS ANGELES

Without shock strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today.

But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and busses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada.

Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety.

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

SHOCK STRENGTH

The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times *on the same spot* from progressively increased heights of 6 inches.

CRUSHING STRENGTH

The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH

When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

BURSTING STRENGTH

In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

SERVES FOR CENTURIES

(*Continued from page 32*)

Weber, Perry Derby, Mng. Partner, Culligan Soft Water Service, 5945 Hazeltine Ave., Van Nuys, Calif. (Jan. '50) *P*

White, Alan R., Owner, Culligan Soft Water Service, 120 N. Bright, Whittier, Calif. (Jan. '50)

Williams, Percy B., Chief Engr., The Welsbach Corp., Ozone Processes Div., 2409 W. Westmoreland St., Philadelphia 29, Pa. (Jan. '50) *P*

Williams, Wesley Benjamin, Public Health Engr., State Dept. of Public Health, 245 State Office Bldg., Atlanta, Ga. (Jan. '50) *P*

Wittenmyer, James D., Supt., Water & Sewage, City Hall, Greenville, Ohio (Jan. '50) *M*

Zinn, Clyde, *see* Hope Water & Light Plant

REINSTATEMENTS

Bingley, William McLean, San. Engr., State Dept. of Health, 2411 N. Charles St., Baltimore 18, Md. (Mar. '34) *P*

Gahn, Henry A., Supt., Water Plant, Box 1209, Fort Pierce, Fla. (July '39)

Guelph, City of, H. S. Nicklin, City Engr., City Hall, Guelph, Ont. (Corp. M. Mar. '24)

Laux, Paul C., Operator, Water Works, 934 Kenwick Ave., Columbus, Ohio (Feb. '26)

Nicklin, H. S., *see* Guelph, City of

LOSSES

Resignations

Anderson, L. E., Billings, Mont.

Arnold, L. E., Salt Lake City, Utah

Bacon, Thomas S., Dallas, Tex.

Burrowes, R. W., Bradenton, Fla.

Calmon, C., Birmingham, N.J.

Carrier, Alfred L., Chicago, Ill.

Chase Brass & Copper Co., Inc., Waterbury, Conn.

Chawner, W. Rupert, Riverside, Calif.

Davis, Stephen Kenneth, Atlanta, Ga.

Dick, John Parsons, Haley, Ont.

Effa, John, Chicago, Ill.

Eshelman, Joseph W., Birmingham, Ala.

Flynn, Martin W., Council Bluffs, Iowa

Gearhart, J. N., Myrtle Point, Ore.

Gibson, William R., Seattle, Wash.

Hagenmaier, Carl E., Los Angeles, Calif.

Harding, William Thomas, Jr., Charlotte, N.C

Henry, Joseph R., White Plains, N.Y.

Herndon, L. Kermit, Columbus, Ohio

Jenkins, Joe E., Houston, Tex.

Keis & Holroyd, Troy, N.Y.

Kettering, Charles B., Inspiration, Ariz.

Kopf, M. George, Dayton, Ohio

Leahey, Edward F., Los Angeles, Calif.

Lucy, Thomas A., Baton Rouge, La.

Macdonald, Frank W., New Orleans, La.

McCarthy, John W., Cheyenne, Wyo.

Melley, William P., Milton, Mass.

Mence, Harry F., Nyack, N.Y.

Neches Butane Products Co., Port Neches, Tex.

New York State Conservation Dept., Rochester, N.Y.

Paulus, Harold J., Arlington, Va.

Perry, E. F., Jr., Nyack, N.Y.

Phillips Petroleum Co., Bartlesville, Okla.

Porter, Cover C., Lufkin, Tex.

Porter, L. Otis, Marion, Ohio

Quilty, Patrick, New York, N.Y.

Reed, Ralph, Watertown, S.D.

Reny, Fred J., Portland, Me.

Revere Copper & Brass, Inc., New York, N.Y.

Ritzel, William J., Pasadena, Calif.

Russell, Alexander, Rochester, N.Y.

Simmons, Frank, Russellville, Ky.

Slagle, Emil C., Minneapolis, Minn.

Smith, Meloy, Rochester, N.Y.

Tarrant, Joseph, Ruislip, Middlesex, England

Taylor, Charles Henry, Long Branch, Ont.

Technical Assn. Pulp & Paper Industry, Cincinnati, Ohio

Tellepsen Construction Co., Houston, Tex.

Texas Acidizers, Inc., Seguin, Tex.

Virginia Smelting Co., West Norfolk, Va.

Wagner, C. F., Portland, Ore.

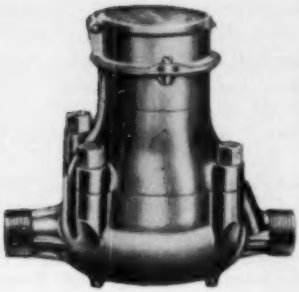
Walker, Merton George, Peoria, Ill.

Whelchel, H. E., College Park, Ga.

White, Eldon L., Olathe, Kan.

(*Continued on page 38*)

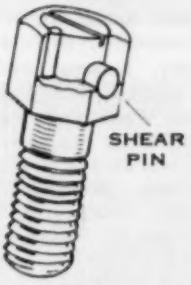
HERE'S WHY CALMET IS



FULLY FROST PROTECTED

Three accepted features in the CALMET Water Meter . . . exclusive frost-proof bolts, split case design and snap-joint measuring chamber . . . provide the most effective and economical protection from freezing yet devised.

When the meter freezes (or pressure exceeds 450 pounds) the pressure snaps the shear pin on the frost-proof bolts allowing both the main case and the measuring chamber to separate without damage to any working part. These frost-proof features, with CALMET'S proved long-life accuracy and low up-keep record, add up to PROFITABLE METERING for you.



• *SALES REPRESENTATIVES— Write for complete details of the CALMET franchise in your territory.*

CALMET WATER METERS

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS

(Continued from page 36)

CHANGES IN ADDRESS

Changes received between December 5, 1949 and January 5, 1950

Abercrombie, J. S., Co., Robert M. Burkett, Sweeny, Tex. (Corp. M. Jan. '40)

Alcoa Mining Co., P.O. 421258, Bauxite, Saline Co., Ark. (Corp. M. Apr. '47)

Allen, John Bolling, Civ. Engr., Water Div., Dist. of Columbia Govt., 14th & E Sts., N.W., Washington, D.C. (Jan. '42) *M*

Baldwin, Dan D., Sparkler Mfg. Co., Mundelein, Ill. (Jan. '46)

Ballou, Arthur F., 1555 Leimert Blvd., Oakland 2, Calif. (Aug. '24) *MPR*

Bosch, Herbert M., Chief, Environmental Sanitation Section, World Health Organization, Geneva, Switzerland (Sept. '29)

Burgess, John, Office Engr., Board of Water Comrs., Box 600, Denver 1, Colo. (Oct. '37) *M*

Cambridge, W. B., Acting Sales Mgr., Hersey Mfg. Co., E & 2nd Sts., South Boston 27, Mass. (Apr. '43)

Collins, Burt W., 622 E. 5th St., Panama, Fla. (Jan. '49)

Collins, Fred C., Water Plant Supt., Walnut Irrigation Dist., 8705 Passons Blvd., Rivera, Calif. (July '42)

Cooper, Robert A., 317 Lafayette Ave., Passaic, N.J. (Apr. '46) *P*

Crosby, Lothrop, 4407 N. 39th St., Tacoma 7, Wash. (Jan. '36) *M*

Cross Water Co., A. V. Handorf Jr., 15825 E. Main St., Puente, Calif. (Corp. M. Jan. '49)

Deckman, William J., Sales Repr. & Engr., Keasbey & Mattison Co., 32 Cooper St., Westmont, Collingswood 7, N.J. (Oct. '47) *MPR*

Dibdin, Frederick J. A., Cons. Engr., 1322 Felicity St., New Orleans, La. (Jan. '49)

Dillon, Richard, Registrar, Water Bureau, Metropolitan Dist., 115 Broad St., Hartford 4, Conn. (Aug. '29)

Dorr Co., The, R. S. Rankin, Water Treatment Div., Barry Pl., Stamford, Conn. (Assoc. M. June '27)

Dunwoody, G. A., Partner, Brink-Dunwoody-Cooper, Register Bldg., Iola, Kan. (Jan. '49)

Durner, Fred J., Distr., Water Works Chemicals, Fred J. Durner Co., 1218 W. Carson St., Pittsburgh 19, Pa. (Oct. '39) *P*

Eddins, Earl W., 12640 Greens Bayou Drive, Houston 15, Tex. (Oct. '47) *P*

Edwards, William R., 956 E. Ridgewood Ave., Ridgewood, N.J. (Apr. '14)

Eliassen, Rolf, Prof. of San. Eng., Massachusetts Inst. of Technology, Cambridge 39, Mass. (Jan. '35) *P*

Erion, Ray, Box 71, Miamiville, Ohio (Apr. '39) *MP*

Fairhurst, William E., Director of Public Works, 37—2nd Ave., Hawthorne, N.J. (July '43)

Ferguson, Gerald W., Sr. San. Engr., U.S. Public Health Service, 2200 Fidelity Bldg., Kansas City, Mo. (Jan. '42) *P*

Frederickson, A. Anton, 2546 E. Heatherbrae, Phoenix, Ariz. (July '47) *MP*

Gardner, Joe H., 1200 Jefferson Davis Highway, Arlington, Va. (Apr. '37) *M*

Gray, Arthur E., Vice-Pres., Pipe Protection Service, Inc., 179 Front St., Elizabeth 1, N.J. (Apr. '47)

Haering, D. W. & Co., Inc., (Mrs.) V. W. Haering, Pres., Box 6037, Harlandale Station, San Antonio, Tex. (Assoc. M. Jan. '44)

Hanna, David McLean, Supt. of Distr., Windsor Utilities Com., R.R. 1, River Canard, Ont. (June '20) *MR*

Heyward, Nathaniel J., 2703 Woodsdale Ave., Baltimore 14, Md. (July '45) *P*

Horn, A. John, Kinki Civ. Affairs Region, APO 25, San Francisco, Calif. (July '39)

Jodaitis, Ladislaus T., 56 Norman St., Milton 87, Mass. (July '43) *P*

Johnson, Leon R., Planning & Zoning Engr., Warwick Co., Hilton Village, Va. (Jan. '43) *PR*

Jones, James R., U.S. Geological Survey, 209 Fidelity Bldg., Boise, Idaho (Apr. '49)

Justice, Leon A., Chemist, Camp Utilities, Camp LeJeune, N.C. (Apr. '46) *P*

Kilborn, R. K., Cons. Engr., 137 Wellington St., W., Toronto, Ont. (July '46)

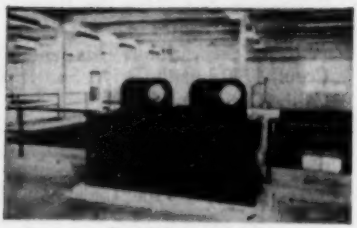
King, Carl H., Asst. City Engr., Box 613, Chinook, Mont. (Oct. '48)

Kleiser, Paul J., 671 Tippecanoe St., Terre Haute, Ind. (Jan. '37) *M*

(Continued on page 40)

New 40 m.g.d. Filter Plant at the City of Savannah, Georgia.
Consulting Engineers:—J. E. Sirrine Company
General Contractors:—Virginia Engineering Company

AGAIN it's
ROBERTS FILTER
SAVANNAH, GEORGIA



Roberts Operating Tables

Upper and Lower Pipe Gallery

Compact Pipe Gallery
Made Possible by Roberts Waste Valves

View of Operating Floor

ROBERTS FILTER
MANUFACTURING CO.
800 COLUMBIA AVENUE • DARBY, PENNA.

(*Continued from page 38*)

Knoxville Power Co., Retail Div., P.O. 421211, Alcoa, Blount County, Tenn. (Corp. M. July '48) *MP*

Krieger, John, Supt., Consolidated Mutual Water Co., 10095 W. Colfax Ave., Denver 15, Colo. (Oct. '41)

Lamb, Carter H., 110 S. Case St., Westmont, Ill. (Jan. '38) *M*

Lawrence, J. Warren, Mgr., Monongahela Valley Water Co., Elizabeth, Pa. (Jan. '46) *M*

Lewis, William M., Pres., Layne-New York Co., Inc., Linden, N.J. (Jan. '37) *PR*

Little, Frank S., 1016 W. Stetson Ave., Orlando, Fla. (Jan. '49)

Machis Alfred, Director of Public Works, Anne Arundel County, 701 Cotter Rd., Glen Burnie, Md. (Apr. '43) *M*

Mylander, Harvey A., Dist. Mgr., De Laval Steam Turbine Co., 603 Grand Ave., South Pasadena, Calif. (Jan. '48)

Nelson, H. Lloyd, Pres., Pontusco Corp., Burlington, N.J. (May '30) *Director '38–'39. Fuller Award '46. MP*

Nesbit, W. S., Johns Manville Sales Corp., 4770 Lucille Drive, San Diego 5, Calif. (Oct. '47) *PR*

Patterson, Richard L., Cons. Engr., 2823 W. Newport Blvd., Newport Beach, Calif. (Sept. '28) *R*

Pearce, Sam B., Pipe Line Contractor, 13801 S. Central St., Los Angeles 2, Calif. (July '47) *M*

Pierce, D. O., Box 805, Galesburg, Ill. (Oct. '45) *MR*

Prager, Frank D., Mfrs. Consultant, The Puromat Co., 30 N. LaSalle St., Chicago 2, Ill. (Oct. '49) *P*

Prichard, George William, Cons. Engr., 220 W. Farmer, Independence, Mo. (Apr. '49)

Rankin, R. S., The Dorr Co., Barry Pl., Stamford, Conn. (Apr. '40)

Roberts, F. C., Jr., San. Engr., U.S. Public Health Service, Western Gulf & Colorado River Basin, Norman Bldg., Ross & LaMarr Sts., Dallas, Tex. (July '35)

Santana, Rogelio A., Engr., Calle 10, No. 265, Vedado, Havana, Cuba (Jan. '39)

Schaefer, Eric, 1661 Capistrano Ave., Berkeley 7, Calif. (Apr. '47) *PR*

Scobey, Fred C., Cons. Engr., Box 755, Berkeley, Calif. (Jan. '32) *R*

Scranton-Spring Brook Water Service Co., 30 N. Franklin St., Wilkes-Barre, Pa. (Corp. M. June '12)

Shephard, Robert O., Soil Conservation Service, 592 Cleveland St., New Albany, Miss. (Jan. '43) *P*

Smith, F. Burton, Florida Utilities Corp., 609 Florida Bank Bldg., Orlando, Fla. (July '43)

Stanley, J. A., Jr., 2426—32nd St., Lubbock, Tex. (Jan. '46) *MP*

Symonds, Allen M., Div. Mgr., Water Works Service Co., Inc., 311 Washington St., Islington, Mass. (July '40) *M*

Telfair, John S., Jr., Regional Engr., State Board of Health, Box 865, Vero Beach, Fla. (July '48)

Thomas, Ariel A., 127 Oakland Ave., Arlington 74, Mass. (Jan. '38) *PR*

Thompson, R. M., Co., R. M. Thompson Jr., Gen. Mgr., 712 Grand Central Ave., Clearwater, Fla. (Corp. M. Apr. '48)

Tuinman, H. T., Cons. Engr., 745 Hoffman St., Hammond, Ind. (Apr. '46) *P*

VanDenburg, John W., George Washington Hotel, 23 Lexington Ave., New York 10, N.Y. (Jan. '46) *P*

Walkinshaw, William M., 86 Glenvale Blvd., Toronto 17, Ont. (Jan. '49)

Watson, Frank Enos, Asst. Dist. Engr., Drainage & Irrigation Div., Hydr. Engrs. Branch, Public Works Dept., Harvey, Western Australia (Jan. '48)

Watson, H. G., City Engr., 801 E. 17th St., Cheyenne, Wyo. (Oct. '38) *Fuller Award '46. MPR*

Wedemeyer, C. C., Mgr., Latrobe Borough Authority, Water Dept., Kaufman & Levine Bldg., Latrobe, Pa. (Apr. '44) *M*

Wendell, Raymond T., 3200 Penbrook Ave., Harrisburg, Pa. (Apr. '44) *M*

Weston, Arthur Daniels, Edgartown, Mass. (July '31) *PR*

Williams, C. A., Mgr., Munic. Water System, 226 Perry St., Helena, Ark. (Jan. '49)

Wilson, Carl, Consultant, Water Quality & Treatment, 112 W. 9th St., Los Angeles 15, Calif. (June '28) *P*

Wilson, Murray A., Cons. Engr., Wilson & Co., Box 937, Salina, Kan. (July '39) *R*

Zaghloul, Hassan Farid, 202 W. Iowa St., Urbana, Ill. (Apr. '46) *MPR*

just don't come too big for Koppers!

▼ Look at the 120-foot section of 66-inch steel pipe pictured above. It's only a *small fraction* of the new 10,000-foot intake pipe line of the Saginaw-Midland Water Project, Saginaw, Michigan. This entire pipe line, inside and out, has been protected against corrosion with Koppers Bitumastic* 70-B Enamel.

From start to finish, Koppers Contract Department handled this tremendous coating job. Some of the 40-foot joints weighed approximately 14 tons; yet Koppers skilled workmen, using specialized spinning equipment, easily coated the pipe's interior with a glass-smooth spun lining. Saginaw can now be certain that its pipe line will be protected against rust, corrosion and tuberculation . . . can be certain that the flow capacity will *remain* high.

Why not submit your corrosion problems to our Contract Department? Write us today.

KOPPERS **PROTECTIVE COATINGS** *T. M. Reg. U. S. Pat. Off.

KOPPERS COMPANY, INC., Dept. 214T, Pittsburgh 19, Pa.

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.W.J.—Sewage Works Journal; W.P.R.—Water Pollution Research (Great Britain).*

ANNUAL REPORTS

Little Rock (Ark.) Munic. Water Works. Annual Report (1948). Capital expenditures of $473,346.23 financed from earnings. Fixed assets $8,819,863.79, total assets $10,484,-110.38, funded debt $5,598,000, surplus $3,928,380.22, operating revenue $944,-711.76, operating expense $386,272.83, net operating income $558,438.93, non-operating revenue $31,547.13, fixed charges $230,508.96, net income $359,-477.10. Cost of water under municipal ownership reduced from 42.3¢ per 1000 gal. in '36 to 34¢, and avg. monthly domestic bill from $1.84 to $1.63. Supply from L. Winona, impounded by earth dam: area 1240 acres, capac. 14 bil.gal., avg. depth 100′. Watershed in Ouachita National Forest, uninhabited but used for hunting and fishing. Streams stocked from fish-rearing pond. Fire-fighting equip. and 2-way radio aid in controlling forest fires. Pipeline, 39″ diam., 25-mgd. capac., 33 mi. to filter plant at 230′ lower el. Free residual chlorination controls org. growths in line. Filter output 13 mgd., increase of 10% over '47. Four 2-mgd. filters under constr., increasing capac. to 23 mgd. Natl. Bd. of Fire Underwriters' classification: fire protection 4th, water supply 3rd class. Pop. served 150,000, 100% metered. Per capita consumption 86 gpd. Water unaccounted for 12.1%. Chem. cost (alum, lime, Cl, NH_3, calgon, soda ash, C) $3.51 per mil.gal. Effluent anal., avg. ppm.: hardness 27, free CO_2 0, color 0, residual Cl 0.33 (chloramine, due to postammoniation); pH value 8.3, threshold odor 7.5, 37° count 1 per ml., coliform index 0.03 per 100 ml. 297 mi. of mains, 2605 valves, 1247 hydrants (avg. spacing 1259′), 25,581 meters. Production costs per 1000 gal.: operating 5.98¢, reserves and taxes 2.12¢, fixed charges 4.84¢, total 12.94¢. Rates 6.75¢–23.5¢ per 100 cu.ft., min. charge for ¾″ meter 94¢ per mo., billed monthly. Hydrant rental $23.33.—*R. E. Thompson.*

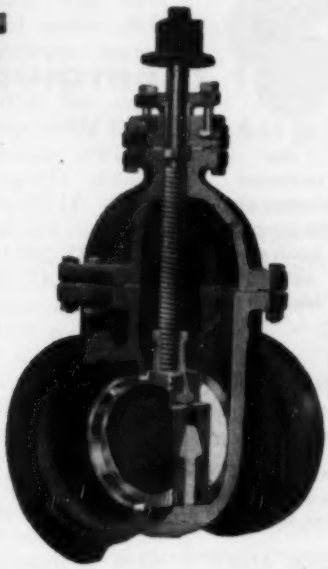
(Continued on page 44)

PALMER

Filter Bed
AGITATORS
Prevent Sand Beds From Cracking
Eliminate Mud Balls
Save Wash Water
Lengthen Filter Runs
Higher Rates of Filtration
FLOC-ALATORS • CONVEYORS • PALMER SURFACE WASH SYSTEMS
STUART CORPORATION, 516 N. Charles Street, Baltimore 1, Md.

for BETTER SERVICE use M & H

Hydrants, Valves
and pipe line accessories



Hub Ends, Mechanical Joint, Flanged or Screwed.

●

M & H Products Include—

FIRE HYDRANTS
GATE VALVES
TAPPING VALVES
WALL CASTINGS
SPECIAL CASTINGS
TAPPING SLEEVES
CHECK VALVES
FLOOR STANDS
EXTENSION STEMS
SHEAR GATES
MUD VALVES
VALVE BOXES
FLAP VALVES
SLUDGE SHOES
FLANGE AND FLARE FITTINGS
FLANGED FITTINGS
B & S FITTINGS
CUTTING-IN TEES

VALVES: A.W.W.A. type, iron body, bronze mounted with double disc parallel seat or solid wedge type. Non-rising stem, outside screw and yoke, or with sliding stem and lever. Also furnished hydraulically operated. Square bottom type operates in any position. All rugged and dependable, made of best material with highest quality workmanship.

HYDRANTS: Standard A.W.W.A. type approved by Underwriters and Factory Mutuals. Dry top, revolving head, easy to lubricate. High efficiency because barrel diameter not reduced and there are no working parts or obstructions in waterway.

FOR WATER WORKS AND SEWERAGE WORKS MATERIALS, WRITE FOR CATALOG NO. 32.

FOR FIRE PROTECTION MATERIALS, WRITE FOR CATALOG NO. 40.

M & H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

HELLIGE

TURBIDIMETER

A TURBIDIMETER WITHOUT STANDARDS

Accurate • Foolproof • Universal

for MEASUREMENT OF TURBIDITY (SiO₂) DETERMINATION OF SULFATE (SO_4) AND OTHER APPLICATIONS

The Hellige Turbidimeter does not require standard suspensions and is not affected by fluctuations in line voltage.

ACCURATE, FOOLPROOF AND UNIVERSAL, this precise instrument is ideally suited not only for turbidity and sulfate determinations of water but for measurements of suspended matter in general. Turbidity measurements can be made down to zero-turbid water.

Those familiar with the cumbersome, long tubes and inconvenient methods employed with older apparatus will appreciate the short tubes of the Hellige Turbidimeter and its simple operation which permits anyone without special training to make determinations quickly and accurately.

WRITE FOR CATALOG No. 8000

HELLIGE

INCORPORATED

3718 NORTHERN BLVD. LONG ISLAND CITY 1, N.Y.

(Continued from page 42)

Denver (Colo.) Board of Water Commissioners Report (1948). Estd. pop. supplied 460,000. Max. consumption 190.7 mgd., avg. 90.66; 198 gpd. per capita. Raw-water conduits 31.3 mi., filtered-water conduits 69.7 mi., Transmountain Diversion Projects 59.25 mi. (canals, tunnels, pipelines, etc.), pump. station capac. 176.5 mgd., mains 905 mi., hydrants 4728, valves 16,947, services 95.662; storage, operating and distr. reservoir capac. 74,204 mil.gal.; filter capac. (4 plants and infiltration galleries) 176 mgd. Meter rates 8–19¢ per 1000 gal., less 10%; outside city 19–23¢; ready-to-serve charge 75¢/mo. up; min. charge $1.80/mo. up; fire hydrant charge to city $22.50 per yr. Capital assets $35,587,085.43, munic. water bonds $19,422,000. Income $4,055,-524.39, operation cost $1,414,148.12, depreciation $624,578.69, interest $778,-233.63, surplus income $1,238,563.95. Cost per mil.gal., including depreciation and 4% interest on investment, $113.91. Cost of operation and maint. of filter plants, including sterilization, $11.65 per mil.gal. Avg. hardness, South Platte source 121.4, Moffat Diversion source 62.4 ppm. Avg. bact. count in treated water from different plants varied from 0.8 to 1.9 per ml., pH from 7.1 to 8.5. Typhoid death rate 0.—*R. E. Thompson.*

Oak Park (Ill.) Water Dept. Annual Report (1948). Supply from L. Michigan, through Chicago water system. Pumping station capac. 24 mgd. Mains 107.4, valves 985, hydrants 1126, services 12,123, meters 12,234. Since '37, losses due to leakage and meter underregistration reduced from 319 to 173 mil.gal. per yr., i.e., from 14.95 to 8.1% of water purchased. Since '42, only $30.43 written off as accts. uncollectable. Pressure at station 30–60 psi., avg. 46.8. Max. consumption 8.8 mgd.,

(Continued on page 46)

IRON REMOVAL

equipment for all water supplies—

Iron is objectionable! The U. S. Public Health Service Drinking Water Standards state that the iron (Fe) and manganese (Mn) content together shall not exceed 0.3 ppm for general household use.

To the pulp and paper mills, tanneries, textile mills, chemical plants and many other industries, a low iron content is a necessity!

You have a specific iron and manganese removal problem! Permutit has the equipment! Permutit's equipment can remove iron by base-exchange, by aeration settling and filtration, or by oxidation through manganese zeolites.

Consult Permutit engineers without obligation! Write to The Permutit Company, Dept. JA-2, 330 West 42nd Street, New York 18, N. Y., or to The Permutit Company of Canada, Ltd., Montreal.

Permutit

FOR 35 YEARS WATER CONDITIONING HEADQUARTERS

~ 9th Edition ~

Standard Methods

~ 1946 ~

286 Pages **Price $4.00**

Orders for the new edition of **Standard Methods for the Examination of Water and Sewage** are now being filled through the publication office at A.P.H.A. headquarters, 1790 Broadway, New York 19, N. Y.

Both cash and credit orders from A.W.W.A. members will receive promptest attention if sent directly to that address. If credit is desired, please indicate your A.W.W.A. affiliation on the order.

•

Published jointly by

AMERICAN PUBLIC HEALTH ASSOCIATION

and

AMERICAN WATER WORKS ASSOCIATION

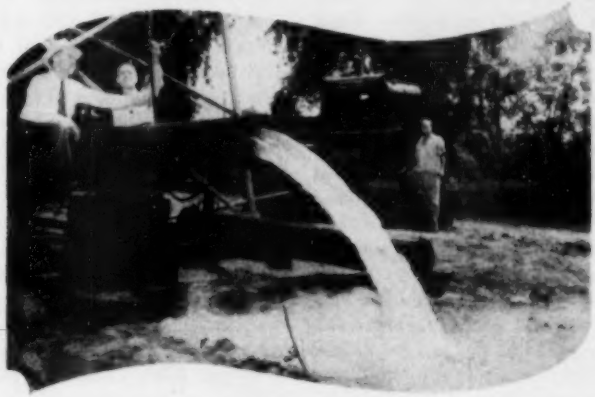
(*Continued from page 44*)

avg. 5.9; 81.9 gpd. per capita. Estd. pop. served 72,000. Fixed assets $1,290,173.42; less depreciation allowance, $1,121,356.18. Total net worth $600,695.74. Income $651,256.55; operation, maint. and depreciation $317,888.23; transfers to municipal funds $247,096.27; net gain $86,272.05. Revenue 30.5¢ per 1000 gal.; operation and maint. 14.9¢; paid to Chicago 7.4¢.—*R. E. Thompson.*

Dubuque (Iowa) Water Dept. Annual Report (Year Ending Mar. 31, 1949). Source of supply, artesian wells and mine tunnel. Pop. ('40 census) 43,892. Mains 125 mi., valves 2418, hydrants 969, meters 10,647. Plant value $2,045,599.43. Total revenue $227,316.49, operation, maint. and depreciation $170,947.70 (cost per 1000 gal. 11.67¢), total expenditures including main and other extensions $231,188.06. Rates 5.4–22.5¢ per 100 cu.ft., min. charge 63¢ per mo. up, according to meter size. Fire protection rates $25 per yr. up. Net profit $56,368.79, 2.7% of plant investment. Expenses increased more than revenue. Net value of plant $2,179,235.17. No bonded indebtedness. Surplus $104,400.14. All water used for fire fighting and other city services provided free and part of civic officials' salaries also paid, reducing tax levy $70,000. Avg. pumpage 5.41 mgd., 0.43 increase. No samples showed gas formers. Hardness about 290 ppm., chiefly bicarbonate. Unaccounted-for water 14.26%. Avg. pressure in business and factory district 88 psi., fire pressure 165.—*R. E. Thompson.*

Louisville (Ky.) Water Co. Annual Report (1948). Company wholly owned by city. Source of supply Ohio R. Pop. served 400,000. Total revenue from water sales $3,040,610.65. Increase in business vol., $113,128.66, absorbed in greatly inflated costs, and net income of $1,156,313.69 was $147,-

(*Continued on page 48*)



What's the Value of

HIGH PRECISION IN MANUFACTURE

Precision is a very important requirement by the Layne organization. It is the only feature that can adequately support skilful engineering and top quality materials. The results of high precision are,—smoother operation, greater quantities of water and lower upkeep cost.

All well water systems are complicated under ground construction projects that require much more than ordinary skill. Fortunately Layne has an abundance of real "know how" that came from years of world wide experience. When they plan a well water system, furnish the pumps and do the work complete, you get a thoroughly dependable job that provides years and years of fine service.

If your plans call for more water in 1950, why not call in Layne first, and obtain the value of their proved "know how" and the satisfaction of dealing with a firm of highest reputation. For catalogs, bulletins etc., address

LAYNE & BOWLER, INC.

LAYNE

General Offices,
Memphis 8, Tenn.

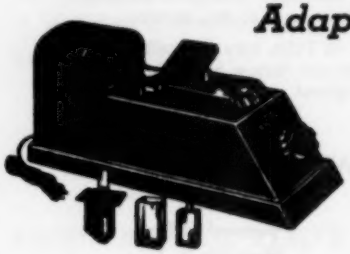
WELL WATER SYSTEMS

(Continued from page 46)

261.56 less than '47. Outstanding bonds $404,000, mature in '50. Total assets $26,803,018.25. During major flood, pump bearings under water. Na aluminate exptd. with as substitute for alum when turbidity low, effecting avg. saving of $30 per day. Severe taste and odor of phenolic origin defied usual treatment by prechlorination and carbon. Frozen meters and services 450 and 53, respectively. Pumping cost per mil.gal. raised 100′ at Riverside (largely elec.) and Crescent Hill stations $4.16 and $8.15, respectively. Cost of purif. $14.64 per mil.gal., $9.20 for chem. Avg. filter run 45.9–58.8 hr., wash water 1.89%, water softened 82.3%. Turbidity reduced from 149 to 0.09 ppm., hardness from 124 to 94 ppm., odor from 1.3 to 0.2, 37° count from 3667 to 1.47 per ml., gas formers from 3957 to 1.15 per 100 ml., *Esch. coli* from 3957 to 0.03 per 100 ml. Delivered water had pH 8.8 and contained 0.54 ppm. residual Cl. Purif. by sedimentation, coagulation with alum, clarification, filtration (capac. 120 mgd.), prechlorination of sedimentation basin influent during low-turbidity periods, postchlorination, pH control by addn. of lime after filtration. 793 mi. of mains. Pressure 45–100 psi. Active services 83,817, 100% metered. Consumption 60.32 mgd., 151 gpd. per capita. Water unmetered and unaccounted for 16%. Operating revenue per 1000 gal. 13.77¢, operating expense 8.35¢, net operating income 5.42¢. Avg. cost of ¾″ service $34.29. Avg. cost of inspecting and testing, and of removing and resetting meters, $0.73 and $1.78, respectively. Avg. cost of meter reading 10.5¢.—*R. E. Thompson.*

(Continued on page 50)

KLETT SUMMERSON
ELECTRIC PHOTOMETER



Adaptable for Use in Water Analysis

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.

There are Hersey Water Meters designed and built to fit climatic conditions. These Meters give accurate service and dependable performance at a minimun maintenance cost. More than 60 years of experience and know-how make this possible.

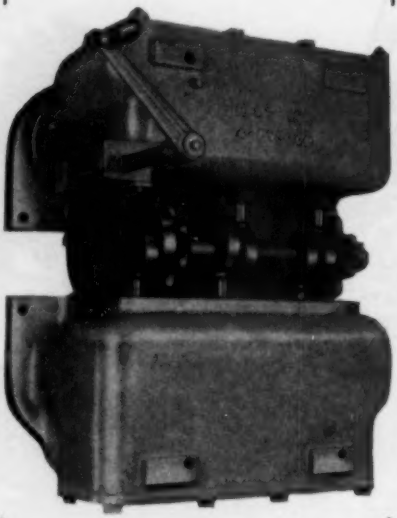
HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO
SAN FRANCISCO — LOS ANGELES

SOFT WATER?
Yes—but

When you buy any zeolite water softener—manual, semi-automatic or fully automatic—insist that it be equipped with an H & T poppet type multiport valve.



This valve, built in all sizes and for all requirements, is a masterpiece of workmanship and operating simplicity. It is available only to experienced water softener manufacturers.

Designed, built and guaranteed by

HUNGERFORD & TERRY, INC.

Clayton, New Jersey

(Continued from page 48)

Detroit (Mich.) Dept of Water Supply. Annual Report (Year Ending June 30, 1948). Water sales increased $252,216.49 but operating expenses increased more than twice that amt. Net income $1,550,225.71. Depreciation allowance insufficient for replacement at present price levels. Total assets $165,946,319.96, of which property, plant and equip. $134,745,127.75. Net debt about $36,000,000. Complaints: low pressure 1824, turbidity 485, taste or odor 47. Main and service leakage 4% of pumpage; municipal unmetered and unaccounted-for water, 9.31%. Revenue-producing pumpage 83.96% of total. Most meters read quarterly. Delinquent balance $52,379.56, about $5000 less than in '47. Broken mains 554, leaking joints 206, leaking services 1599, frozen hydrants 1127. Services 484,737, 99+% metered. Cost of testing and installing ⅝" meters $0.12 and $11.78, respectively, and of repairing those damaged by frost, hot water and wear and tear $3.36, $3.71 and $3.11, respectively. Avg. pumpage 354.5 mgd., 3.73% increase, max. 546, min. 250.7. Estd. avg. pop. served 2,415,216, about 25% suburban; avg. per capita consumption 147 gpd. Purif. by prechlorination, coagulation with alum, rapid sand filtration and final chlorination. Avg. operating data, Water Works Park Plant: wash water 3.4%, runs 33 hr., rate 159 mgd., alum 9.4 ppm., Cl 0.91 ppm. to raw and 0.15 to filtered; 37° count reduced from 24 to 0, coliform M.P.N. from 54 to 0 (100 ml.), turbidity from 11 to 0.2; effluent threshold odor 1. Springwells Plant: wash water 6.6%, runs 35 hr., rate 141 mgd., alum 10.2 ppm., Cl 1.14 to raw and 0.15 to filtered, activated C (Feb. only) 1.34 ppm.; 37° count, coliforms and effluent threshold odor 0; turbidity reduced from 13 to 0.1 ppm. Residual Cl in both effluents 0.45 ppm. Of 4248 samples collected

(Continued on page 52)

CHECK YOUR REQUIREMENTS

with these advantages of Reinforced Concrete Cylinder Pipe for main water transmission lines

1. Combines the physical strength and characteristics of steel with protective features and permanency of well-made concrete.

2. Under normal bedding and backfill conditions, will successfully withstand external or trench loads up to 10 ft. of cover. Greater loads are safely provided for by compacted backfill, cradling or additional steel reinforcement.

3. Has ample strength for the occasional concentrated loading which is sometimes met in practice.

4. Will remain water tight under conditions of foundation settlement or soil movement within the limits generally met in water works practice.

5. Has a long life with freedom from corrosion or deterioration. Concrete encasement protects steel cylinder and reinforcement from electrolytic action and deleterious ground water.

6. Conservative design basis and assumed unit stress of this class of pipe allow ample factor of safety for all normal conditions of service including surge and water hammer.

7. In event of earthquake, sudden or extreme increases of pressure, or other disturbances, pipe will neither burst, shatter, nor discharge its full flow of water.

8. If surges beyond design operating limit, or other extraordinary pressures cause cracks to open up in concrete lining or encasement, they will close and seal after these heavy pressures have been relieved, wherever elastic limit of steel has not been exceeded.

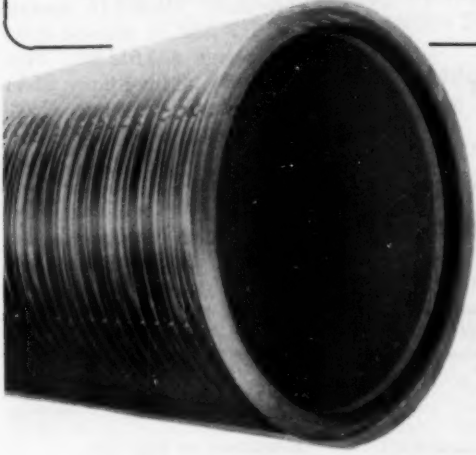
9. Rugged construction provides ample strength to withstand all normal handling conditions.

Complete information is available upon request

American PIPE AND CONSTRUCTION CO.

Concrete pipe for main water supply lines, storm & sanitary sewers, subaqueous pipe lines

P.O. Box 3428, Terminal Annex, Los Angeles 54, Calif. Main Offices and Plant - 4635 Firestone Boulevard, South Gate, California. District Sales Offices and Plants - Oakland - San Diego - Portland, Oregon



COMBINES strength of STEEL with permanency of CONCRETE

Available in three types to meet the requirements of pressure transmission of water: American Concrete Cylinder Pipe, Lock Joint Concrete Cylinder Pipe (non-prestressed), and Lock Joint Prestressed Concrete Cylinder Pipe. All employ the Lock Joint Rubber Gasket Joint type of closure. Phantom view shows how steel cylinder and reinforcement cages are encased in concrete wall of 57" Lock Joint Cylinder Pipe, non-prestressed.

SOLVAY
Trade Marks Solvay and S Registered U.S. Pat. Off.

FOR
WATER
CONDITIONING

For Water Softening
...SOLVAY Soda Ash

For Water Purification
...SOLVAY Liquid Chlorine

For Water Technical Service
...Call SOLVAY

SOLVAY SALES DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

BRANCH SALES OFFICES

Boston • Charlotte • Chicago • Cincinnati
Cleveland • Detroit • Houston • New Orleans
New York • Philadelphia • Pittsburgh
St. Louis • Syracuse

(Continued from page 50)

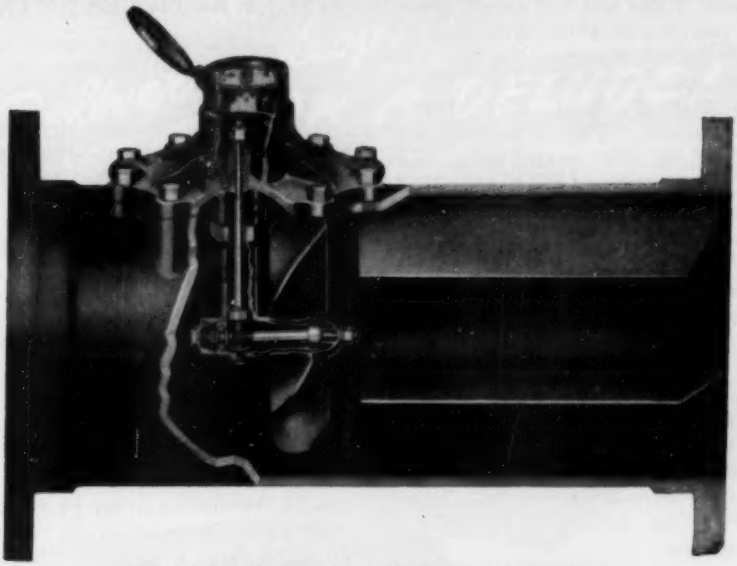
from distr. system, 10 positive for coliforms. Mi. of mains 5153. Accident frequency rate reduced 17.6% and severity rate 32% compared with '47. Rates per 1000 cu.ft.: first 10,000 cu.ft. per mo., 78¢; next 90,000, 60¢; over 100,000, 48¢; and in addn. 11¢ per 1000 cu.ft. for sewage disposal, and service charge varying from 24¢ for ¾" meter up. Min. bill $1.50 per quarter. Suburban rates 82, 63 and 50¢, respectively, plus 25¢ sewage disposal and 50¢ and up service charge. Min. bill $2.32. Income and expense per 1000 cu.ft., revenue water basis: gross revenue 76.6¢ (water sales 71¢), production cost 31.1¢, fixed charges 26.4¢. Sewage disposal plant operating data included.—*R. E. Thompson.*

Wyandotte (Mich.) Dept of Munic. Service. Annual Report (Year Ending Sept. 30, 1948). Supply from Detroit R. Poln. increasing. Water has always met U.S.P.H.S. standards but medicinal tastes and odors due to industrial wastes troublesome. ClO_2 treatment, adopted Aug. '45, successful. Filter plant extension in progress will increase capac. 70%. Hardness 114.7, dissolved solids 140.4 ppm. Total assets $2,197,069.64, long-term debt $427,919, city's equity $1,-260,972.29. Operating revenue $191,-452.37, depreciation $36,412.16, operating expense $117,132.15, interest $20,-633.67, net income $23,612.99. Pop. 38,000. Fixed capital investment $6.11 per capita, operating revenue $5.04, net operating revenue $1.00. Max. consumption rate 9 mgd., avg. 4.36, per capita 115 gpd. Total operating expense 9.6¢ per 1000 gal., purif. expense 2.6¢, operating revenue 12¢, net operating revenue 2.4¢. Mains 93.4 mi., valves 961, hydrants 759, meters 8339. Filter capac. 6 mgd., storage 1.9 mil.gal.—*R. E. Thompson.*

Portsmouth (Va.) Water Dept. Annual Report (1948). Supply

(Continued on page 54)

SPARLING MAIN-LINE METERS



SIMPLICITY

A Sparling Meter is as easy to install on your main line as a length of the pipe itself. It is as easy to read as a house meter. And it is perfectly obvious—simplicity itself—in its action. The flow turns the propeller and this, through ball bearings and gears, advances the Totalizer.

Readings accurate within 2 per cent are assured with a minimum of cost for years to come.

Quotations and Bulletin 310 come at your request

J. W. SPARLING *Manufacturer of* WATER MEASURING EQUIPMENT

LOS ANGELES 54..Box 3277 Terminal Annex
CHICAGO 8.....1500 South Western Ave.
BOSTON 8..... 6 Beacon Street
622 Broadway..... CINCINNATI 2
101 Park Avenue..... NEW YORK 17
1932 First Avenue..... SEATTLE 1
DALLAS 1.....726 Reserve Loan Life Bldg.

(Continued from page 52)

from L. Kilby and L. Cahoon, filtered and treated with alum, lime, C and Cl. Filter capac. 18 mgd. Surface wash equip. being installed. Mains 305 mi., over 25% 2" diam. Fire hydrants 1104, meters 22,722. Operating cost $302,955.86, debt service $181,723.58, additions $167,452.41, total $652,-131.85. Revenue $774,823.08. Outstanding bonds $265,000, sinking fund $155,611.62, net debt $109,388.38. Value of water works property $6,-123,672.30, less depreciation of $1,-067,194.30. Cost per 1000 gal.: operation and debt service 13.1¢, capital addns. 4.5¢, total 17.6¢; revenue, from Portsmouth 20.6¢, from Suffolk 22.9¢. Water filtered 3726 mil.gal.—376 supplied to Suffolk, 3232 to Portsmouth. Water unaccounted for in former 22.2%, in latter 12.2%.—*R. E. Thompson.*

PROOF OF "STERELATOR EFFICIENCY"

NO JOB TOO LARGE

SEND US COPY OF SPECIFICATIONS

Actual Users—THE BEST PROOF OF ALL—Prove our claims that Everson SterElatorS are DEPENDABLE · SAFE · EFFICIENT Easy to operate at LOW MAINTENANCE COST.

Everson SterElatorS METER-MIX-FEED Chlorine accurately for all water sterelizing requirements. Furnished for manual or automatic operation.

Everson SterElatorS utilize a high vacuum. The indicating FLOW METERS have a 10 to 1 ratio.

SterElatorS by Everson

EVERSON MANUFACTURING CORPORATION
221 West Huron Street, Chicago 10, Illinois

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Nevada Utilizes Modern Methods in Forecasting Runoff From Snow Cover. KRISTIAN TONNING. Civ. Eng., **19**:10:22 (Oct. '49).

Has the Small-Area Flood Been Neglected? LLOYD L. HARROLD. Civ. Eng., **19**:10:38 (Oct. '49).

Curves Solve Reservoir Flood Routing Equations. KENNETH E. SORENSEN. Civ. Eng., **19**:11:56 (Nov. 1949).

Frozen Water Lines. ANON. Am. City, **64**:11:114 (Nov. 1949).

Use of Antibiotics in the Presumptive Medium for Water Analysis. SYDNEY C. RITTENBERG & JOHN H. SILLIKER. Am. J. Pub. Health, **39**:12:1553 (Dec. '49).

Oxygen Removal From Water by Ammine Exchange Resins. G. F. MILLS & B. N. DICKINSON. Ind. Eng. Chem., **41**:12:2842 (Dec. '49).

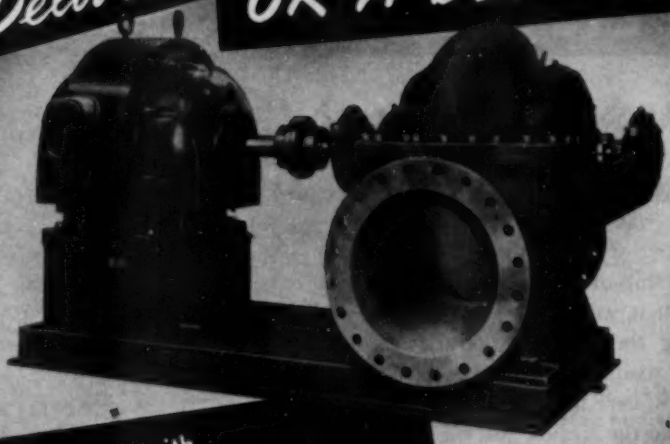
High-Velocity Flow in Open Channels—A Symposium. ARTHUR T. IPPEN; ROBERT T. KNAPP; ARTHUR T. IPPEN & JOHN H. DAWSON; & HUNTER ROUSE, B. V. BHOOTA, & EN-YUN HSU. Proc. A.S.C.E. **75**:9:1287 (Nov. '49).

Stream Standards and Their Practical Application. CHARLES C. AGAR. Sew. Wks. J., **21**:6:1050 (Nov. '49).

Permissible Water Pollution at Combined Sewer Overflows. GUNNAR AKERLINDH. Sew. Wks. J., **21**:6:1059 (Nov. '49).

Water Pollution Control by Interstate Cooperation—A Symposium. WARREN J. SCOTT, ARTHUR D. WESTON, SETH G. HESS, JAMES H. ALLEN & ROBERT N. CLARK. Proc. A.S.C.E. **75**:9:1251 (Nov. '49).

Deliver a drop... OR A DELUGE!



with

Economy

DOUBLE SUCTION PUMPS

. . Capacities from 10 to 15,000 G.P.M. at heads to 300 feet.

Economy Double Suction Pumps meet your needs . . . for most any volume. More than 1500 ratings designed for every type drive assure you the right pump for your requirements . . . with these advantages:

1. Complete rotor may be removed without exposing bearings which are enclosed in removable cartridges.
2. Shaft sleeves sealed to prevent leakage between sleeve and shaft.
3. Modern hydraulic design.
4. Flanged wearing rings "L" shaped, inward flow.
5. All parts made to limit gauges for interchangeability.
6. Unusually effective water seals.
7. No threads in center of shaft to start fatigue failure.
8. Large wells for lubrication with flushout for old lubricant.

For full details write Dept. AG-2 for Catalog 1147-A. Centrifugal, axial and mixed flow pumps for all applications.

Economy Pumps Inc.

DIVISION OF HAMILTON THOMAS CORP. HAMILTON, OHIO

Section Meeting Reports

Chesapeake Section: The first annual conference of the Chesapeake Section was held at the Wardman Park Hotel, Washington, D.C., on November 2–4. Although the section was organized last year with a membership of about 160, after losing an equal number from eastern Pennsylvania, it was able to attain a registration for this meeting of 196, not counting the ladies registration which amounted to about twenty. The total of membership at the start of the meeting was 209, and 118 of the members were actually in attendance. This turnout was gratifying to the officers of the section and the members of the committees who worked hard to arrange an interesting conference.

There was the usual Get-Together Party on Wednesday evening, November 2nd, at which time registration was begun. The session was opened Thursday morning with an address of welcome given by Lt.Col. C. H. Whitesell, assistant engineer commissioner of the District of Columbia. E. A. Schmitt, section Chairman, followed with a short response and then introduced the first speaker, S. K. Love of the U.S. Geological Survey, who gave a very interesting paper, made especially impressive by the use of charts, on "Quality Characteristics of Water Supplies in Middle Atlantic States." R. L. Jenkins, U.S. Corps of Engineers, gave a talk on "Practical Safety in Water Works," which was followed by a panel discussion on "Operating Aspects" led by H. R. Hall of the Washington Suburban Sanitary Commission. In this panel D. M. Watt, Corps of Engineers, discussed "Plant Shutdowns for Repairs and Improvements," F. Gosnell of Laurel, Md., spoke on "Experiences at a Small Plant," and J. M. Jester covered "Summer Water Problems." Some discussion from the floor followed.

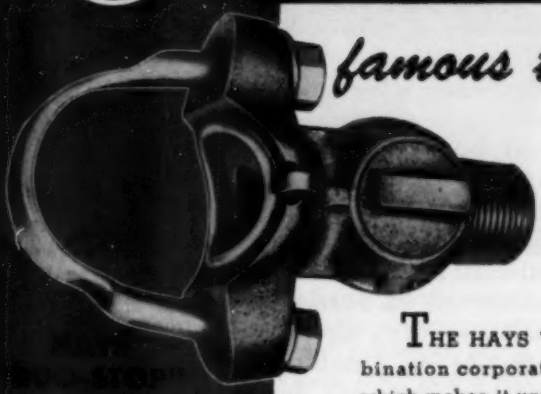
At this time the meeting adjourned to the Dalecarlia Filter Plant where an oyster luncheon prepared by "Pop" Crandell was enjoyed by 136 hungry water works men. After a short inspection of the Dalecarlia Plant, where the new 14-mil.gal. double-deck sedimentation basin was open, the group reassembled at the hotel for the afternoon session which was presided over by Schuyler Blackburn of Baltimore.

A short film, "Life Stream," made by the Kansas City Water Dept. opened the session. A.W.W.A. President A. P. Black appeared before the

(*Continued on page 58*)

WATER SERVICE PRODUCTS

famous throughout the world



THE HAYS "Duo-Stop" is a combination corporation stop and saddle which makes it unnecessary to buy corporation stops and service clamps or saddles separately. It is designed to install on 2 inch mains, either cast iron or steel . . . requires no tapping of the main and can be installed without interruption of service. It can be supplied with outlet for iron pipe, copper service, or various types of thread.

Hays Manufacturing Company is one of the largest making a complete line of water service products, and throughout eighty years the name HAYS has been a guarantee of quality. Every HAYS fitting is precision machined, specially lubricated for enduring operation, and hydrostatically tested at 200 pounds or more. All corporation stops can be installed with any standard tapping machine equipment.

HAYS Main Drilling Machine for installing HAYS "Duo-Stop." Ask for our new complete catalog of water service products.

COPPER BRASS LEAD IRON

HAYS WATER WORKS PRODUCTS

HAYS MANUFACTURING CO., ERIE, PA.

(Continued from page 56)

assembly and in the usual Black way gave one of his most interesting discussions, dealing primarily on corrosion factors in water, which he illustrated to the satisfaction of all by a chalk talk.

Dr. Charles Renn of Johns Hopkins Univ. offered an interesting and instructive discussion of "Biological Problems of Middle and Old Age Reservoirs," which he illustrated with lantern projections of actual biological materials. The "Expansion of Elkton, Md., Water Supply System" was presented by R. T. Regester and J. S. Strohmeyer discussed the "Lazaretta–Fort McHenry–Fairfield Subaqueous Water Main."

A cocktail hour followed in the Burgundy Room, sponsored by the manufacturers association and manufacturers representatives. The club room type of entertainment prevailed during the entire meeting and gave ample opportunity for new members to meet the older ones.

On Thursday evening 206 members and ladies attended a very delectable banquet in the Continental Room. The event was characterized by all present wearing colored caps and was followed by a dance at which prizes were awarded. Dr. Black also gave a short pep talk after the banquet.

Friday morning's meeting was presided over by Carl Hechmer and opened with a short but very interesting British film, "Not a Drop of Water." C. M. Hitchcock gave a talk on "Anthrafilt History and Development at Cumberland." F. M. Niles of Greeley and Hansen presented a very carefully prepared report on the subject "Obtaining Technical Services For Small Communities," and certainly covered the subject well. W. H. Cary, director, D.C. Health Dept., then gave another of his timely talks on "Occupational Health Hazards in Water Works Systems," covering about every hazard that exists.

The second panel, on "Sanitary Districts," was led by Ed Cotton of the Potomac River Basin Commission. Subjects discussed were: "Procedure For Organizing Sanitary Districts," by Alvin Pasarew, director of the State Planning Com., Baltimore, "Financing Projects," by N. L. Smith of Baltimore, and "Public Authorities in Pennsylvania," by J. R. Hoffert, chief engineer, State Health Dept., Pa.

After luncheon recess the Friday afternoon session was opened again by E. A. Schmitt, and a business meeting was held.

A panel, on "Looking at a Distribution System," was conducted by David Auld, superintendent, Water Division, D.C. The topics included "System Design Practices and Procedures" by R. L. Orndorff, "Application of Maps to System Planning" by J. B. Allen, and "Operations to Increase Efficiency of Existing Systems" by J. R. Mitchell—all of the District Water Division. This panel aroused a great deal of interest and was attended by as large a group of the membership as any during the entire meeting—even at that late hour, a fact which speaks for itself.

(Continued on page 60)

WHY FAMOUS

RENSSELAER

DOUBLE DISC

GATE VALVES

open easier...

seat tighter!

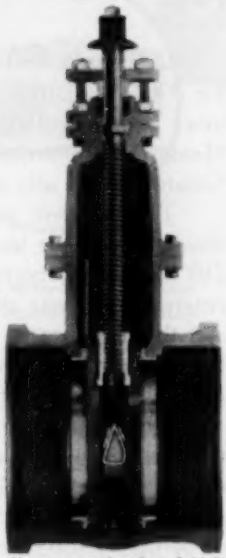
IN OPENING, THE THICK (A) SIDE OF THE STEM NUT LIFTS THE GATE ON ONE SIDE FIRST, MECHANICALLY BREAKING SEAL

GATE ON SHORT SIDE (B) OF WEDGE IS PULLED FIRST, LOOSENS EASILY. IN CLOSING, LONG SIDE (C) OF WEDGE CAUSES POWERFUL SEATING FORCE ON THAT SIDE.

The principles of the long Wedge for greater seating power and the short Wedge for easier unseating apply to RenSSelaer Valves in sizes 10" and larger. But in ALL sizes of these famous Valves, ONE gate is ALWAYS lifted FIRST, mechanically releasing the wedges, so opening is positive. Wedging action does not seat gates until they are in *"fully closed"* position, so sliding frictional wear is minimized.

But ease of operation is only one feature of RenSSelaer Valves. SOLID BRONZE is used liberally throughout – in stems, stem nuts, wedges, seat and gate rings, glands and stuffing box nuts. Castings are high tensile strength corrosion-resistant iron. INTERCHANGEABILITY of parts insures low maintenance cost. Thousands in perfect service for over 65 years.

Experienced Field Representatives are at your call to bring you the benefit of RenSSelaer experience in Valves AND Hydrants. Their service puts you under no obligation. Call our nearest office.



Above cross-section shows 2-sided wedge on valves 10" and larger

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER

Gate Valves • Square Bottom Valves • Tapping Valves and Sleeves
Hydrants • Check Valves • Air Release Valves

RENSSELAER VALVE COMPANY • TROY, N. Y.

Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle, Waco

(*Continued from page 58*)

The final series of papers consisted of a last panel on "Benefits of Short School Courses for Management and Plant Operators" led by Professor J. C. Geyer of Johns Hopkins Univ. The topics included "Status of Short Course School for Chesapeake Section Water Works Operators" by [the late] Carl Hechmer, "Importance of Participation by Municipal and Private Officials and Operators" by I. M. Glace, "Future Short Course School Activities in Relation to State Health Departments" by G. L. Hall, "Reflections and Comments on Short Course Schools" by A. H. Cline. After some discussion the conference was adjourned by Chairman Schmitt.

Entertainment was also provided for the Ladies, who were visitors on Thursday noon at the WRC Radio Station, after which a luncheon was served at the Washington Engineers Club. A bridge game at the club was the afternoon event for the ladies.

CARL J. LAUTER
Secretary-Treasurer

California Section: A total of 831 members and guests registered for the 30th Annual Conference of the California Section in Sacramento October 25 to 28, 1949. The technical sessions and exhibits were held in Memorial Auditorium with dinners and lunches being held at the Hotel Senator, which also served as the headquarters hotel.

The excellent ladies' program provided, plus memories of a pleasant time at Riverside last year, no doubt were large factors in attracting the 210 ladies who registered during the conference. Wednesday's tea and entertainment was attended by 100 ladies, the Thursday luncheon by 130, and the luncheon at the Tuesday Club on Friday by 132. Following the Friday luncheon there was a tour through Sutter's Fort and its museum features of Gold Rush days.

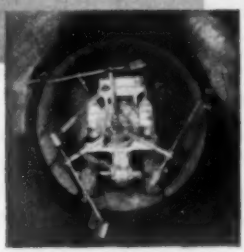
Chairman Claude Faw of the Golf Committee arranged for the annual tournament to be held at the Del Paso Country Club on Wednesday morning. Forty-four members and guests competed in three flights for very attractive prizes which were awarded at the Wednesday night dinner. Approximately fifty members and guests were present at the lunch in the clubhouse following the golf tournament.

For the first time, a special meeting of public utility district representatives was held during the conference. George Yackey, of the Fallbrook Public Utility District, presided.

On Wednesday evening 382 members and guests attended the All Division dinner. Mayor Belle Cooledge officially welcomed the California Section to Sacramento and President Black was the principal evening speaker. "Doc" stressed the necessity of selling our industry to the public and briefly discussed the Association's publicity program.

(*Continued on page 62*)

where performance counts . . . count on Centriline



CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

142 CEDAR STREET
NEW YORK 6, N. Y.

Branch Offices in all Principal Cities in the United States and Latin America.

In Cincinnati's program to recondition its water mains for greater efficiency and economy, Centriline has recently completed its fifth contract.

A total of more than 68,000 feet of cast iron pipe has been cleaned and uniformly lined with dense cement mortar in this city. Pipe sizes were from 24" to 48". On the last job, the average speed of lining was better than 1,000 feet per day—resulting in minimum interruption in water distribution.

Cincinnati has found that Centrilining pays. It will establish and maintain a high coefficient, reduce pumping cost, stop all leakage and terminate deterioration. Consult Centriline's experienced hydraulic engineers. A 28-page illustrated bulletin is also available on request.

CEMENT MORTAR LININGS FOR WATER MAINS CENTRIFUGALLY APPLIED In strict conformity with A. W. W. A. Specifications.

(Continued from page 60)

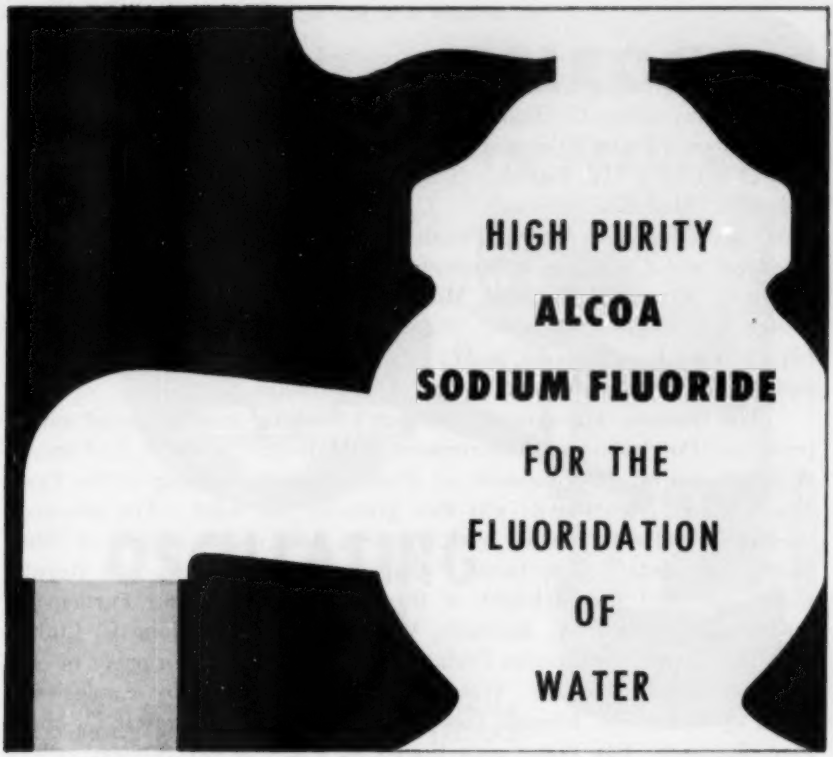
The first presentation of section citations and an award were made at this dinner. Seven of the fifteen recipients of the Old Timers Citation were present to receive the certificate in person. The section was particularly honored by the presence of Mrs. George A. Elliott at the dinner to make the first presentation of the George A. Elliott Memorial Award. The recipient was Roy O. VanMeter in recognition of outstanding services in securing legislation protecting California water supplies.

Chairman Grayson opened the technical sessions at 2:30 Wednesday afternoon and the first paper entitled "Trench and Backfill Requirements and Practices" was presented by Harmar E. Davis, Director, Institute of Transportation and Traffic Engineering, University of California, Berkeley, and discussed by Max K. Socha. A panel discussion on "Problems of Cooling Water Supply and Disposal" was presented by Guy B. Cornell, who discussed the water supply problems, and J. Carl Jennings, who spoke on "Disposal of Waste Cooling Water."

Three parallel programs were in session throughout Thursday, presented by the Purification Division, the Plant Management and Operations Division, and the Business Management Division. The Plant Management and Operations Division's morning program opened with a panel discussion on accounted for water, under the leadership of Leslie A. Hosegood. The panel was divided into three parts with O. A. Gierlich, giving a "Questionnaire Summary of Experiences of a Number of Water Works"; C. Kenyon Wells, discussing "The Experiences of Long Beach in Accounting for Water"; and G. T. Luippold reading a discussion prepared by E. D. Case on "Water Waste Surveys as a Means of Reducing Unaccounted-for Water." W. L. Berry then presented a paper entitled "State Water Plan—Requirements for all Beneficial Uses." The afternoon session opened with a paper by Alexander C. Rener on "The Practical Aspects of Water Hammer and Its Correction." "New Developments in Wells for Supply and Recharge" was presented by C. E. Jacob and the afternoon session closed with a panel discussion on "Small Water Works Operation Problems" led by R. W. Adcock. Participants on the panel were Harold R. Hushbeck, Loy E. Cook, James A. Wyatt and Arthur W. Holsworth.

The opening paper on the Purification Division parallel session was prepared jointly by Lee Streicher and A. E. Bowers, on the subject, "Cation Exchangers for Municipal Water Softening" (see January JOURNAL, p. 81). The second paper on "Maintenance of Free Residual Chlorine Throughout a Distribution System" was in two parts, with K. W. Brown discussing "Experiences at Santa Rosa" and Carl Wilson discussing "Experiences at Glendale." Ray L. Derby discussed "Treatment of Water Containing Radioactive Wastes" which was followed by a "Discussion and Demonstration of Radioactivity Protection Devices" given by Fred R.

(Continued on page 64)



ALCOA Sodium Fluoride, like all other Alcoa Chemicals, has a uniform high degree of purity. It may be used with confidence for the fluoridation of water supplies. ALCOA Sodium Fluoride flows freely . . . is easy to handle . . . dissolves at a uniform rate. Besides that, ALCOA is a *dependable* source of supply.

If your community is fluoridating its water supply—or is considering doing so—let us discuss with you the properties of ALCOA Sodium Fluoride that make it particularly suitable for your use. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 624 Gulf Bldg., Pittsburgh 19, Pennsylvania.

Alcoa Chemicals

ALCOA

ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

(Continued from page 62)

Ingram. The afternoon session was opened with a paper by Jack W. Pratt, on "Operating Characteristics of Upflow Clarifiers" and a prepared discussion by Oscar C. Blumberg. W. M. Tibbett gave an amusing dissertation on "Water Operated Gadgets" followed by a discussion of the subject led by E. W. Barbee. The program closed with a discussion of "Modern Analytical Methods." J. J. Connors, Bacteriologist-Chemist, East Bay Municipal Utility District, Oakland, discussed "Advances in Chemical and Colorimetric Methods" (see January issue, p. 33), while Harry G. Neumann, Research Microbiologist, Department of Water and Power, Los Angeles, discussed "Possibilities of New Bacteriological Techniques" (see January issue, p. 57). Time allowed a very short floor discussion of the general subject, led by J. R. Rossum.

The Business Management Division's morning session opened with a paper on "Purchasing and Procurement of Materials" by H. R. LaFortune. A paper entitled "Development of Punch Card Accounting in the Long Beach Water Department" was then given by Joe Kerr. The afternoon session opened with a paper by Richard L. Boke on the subject of "Raw Water Contracts." The panel discussion "Uniform Rules and Regulations" provided the highlight of this division's program. Participants on the panel were R. C. Kennedy, W. C. Welmon, and John C. Luthin.

The General Session on Friday morning opened with a paper of considerable interest entitled "Water Well Redevelopment by Explosives," given by Robert M. Ebaugh (see this issue, p. 171). Everett D. Howe then discussed "Sea Water as a Source of Fresh Water Supply," which was followed by a discussion led by W. W. Aultman. In the absence of Dr. A. C. Hollister, E. A. Reinke discussed "Poliomyelitis and Water Supplies." The technical sessions closed with an afternoon panel on "Problems of Long Transmission Lines." Carl A. Lauenstein discussed the "Location and Right-of-Way Problems of San Francisco's Bay Division Pipe Line No. 3," and J. W. Trahern discussed "Pertinent Features of Above-Ground Sections of the Mokelumne Aqueduct" (see this issue, pp. 199 and 189).

At the Executive Committee Meeting held on Thursday evening, a decision was made to publish a newsletter twice annually, which would include abstracts of papers given at Section meetings not published in the JOURNAL and other items of interest.

The Conference closed with the annual Friday night banquet at which the Water and Sewage Works Manufacturers Association presented motion picture equipment to James R. Barker, retired Exhibits Committee Chairman, in appreciation for his many years of service in that capacity.

H. C. MEDBERY
Secretary-Treasurer

(Continued on page 66)

IT'S ALWAYS OMEGA

THE LAST WORD IN FEEDERS

OSCILLATING THROAT

This unique feeding mechanism is one of the reasons why OMEGA UNIVERSAL FEEDERS are so dependable and accurate. Lumps, twine, trash, fine powder, or coarse grit — the oscillating throat takes them all with equal ease. Large throat opening prevents clogging . . . plate type agitators stop arching of light powdered chemicals, too. The net result is high volumetric accuracy — within 3% when feeding most types of dry materials.

If you want a chemical feeder that's simple, easy to operate, and virtually trouble-free . . . get the Omega Universal that fits your requirements. Available in three sizes for rates from 1 to 5000 lbs. per hr. For complete information and Bulletin, address Omega Machine Company, (Division of Builders Iron Foundry), Providence 1, R. I.

OMEGA PRODUCTS

Belt-Type Gravimetric Feeders
Loss-in-Weight Gravimetric Feeders
Universal Feeders
Precision Solution Feeders
Disc Feeders
Rotodip Solution Feeders
Rotolock Feeders
Lime Slakers
Laboratory Stirrers
Dust Collectors
Chemical Elevators

THE LAST WORD IN FEEDERS

OMEGA

(Continued from page 64)

Florida Section: With the largest registration in its 23 years, the Florida Section held its annual meeting at Orlando on November 14–16. Attending the session were 174 interested water works men.

The Orlando Utilities Commission, representing the City of Orlando as host, prepared an outstanding entertainment program, including a barbecue for about 250 persons, the annual banquet and dance, a luncheon for the ladies, the annual men's luncheon and various other activities. At the men's luncheon, which was held in honor of A.W.W.A. President A. P. Black and Mr. Emiel A. Croll, a plaque given by the Association was presented to Mr. Croll (see cut). Mr. Croll is the senior member of the American Water Works Association, having first joined in September 1893. A brief speech of presentation was made by Dr. Black, with the acceptance by Douglas Croll, son of the senior member.

Bronze Plaque Presented to Senior Member Emiel A. Croll

The text reads: "Presented to Emiel A. Croll by the American Water Works Association to celebrate his fifty-six years of membership in the Association, 1893–1949." The former superintendent of the Iron Mountain, Mich., water works joined A.W.W.A. when it was in its thirteenth year.

The technical program in the words of President A. P. Black was the strongest in the section's history. It included papers on ground water resources, water works finance, water works developments in Florida and Cuba, and a panel discussion on distribution system operation and maintenance.

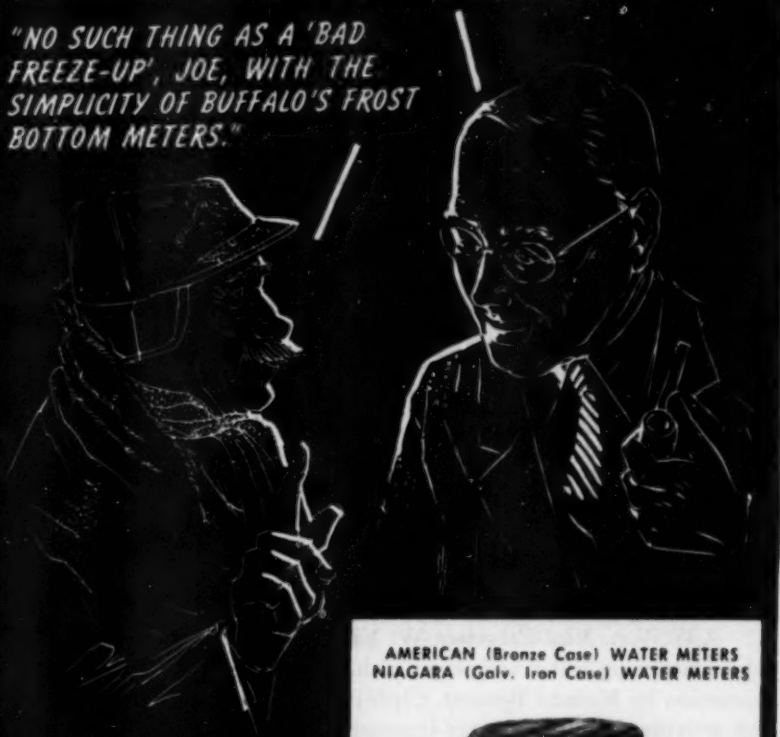
During the course of the meeting, Dr. Black praised the administration of retiring Chairman Wylie W. Gillespie and indicated that the Florida Section ranked high in membership gain over the past decade. New By-Laws were adopted for the section, replacing the original By-Laws formulated when the section was formed almost a quarter century ago.

The close cooperation between the Florida and Cuban Sections was indicated by the interest of a delegation of eight Cuban Members. Prob-

(Continued on page 68)

"BAD METER FREEZE-UP, HARRY?"

"NO SUCH THING AS A 'BAD FREEZE-UP', JOE, WITH THE SIMPLICITY OF BUFFALO'S FROST BOTTOM METERS."



Any freeze-up is less trouble when simply-designed American or Niagara FROST BOTTOM Meters are used. All working parts are fully protected against frost damage, and meters can be returned to service with a minimum of cost and delay.

AMERICAN (Bronze Case) WATER METERS
NIAGARA (Galv. Iron Case) WATER METERS

BUFFALO METER CO.

2914 MAIN STREET, BUFFALO 14, N. Y.

(*Continued from page 66*)

lems of mutual interest to the two sections were discussed and a joint meeting of the two is expected in the very near future.

A. E. WILLIAMSON
Secretary-Treasurer

Arizona Section: An excellent turnout of 72 per cent of Arizona Section members marked the 1949 Fall Conference of the section at its meeting in Yuma, November 11–13. Total registration was 181, an all-time high for the organization.

Chairman Anton Frederickson presided over the opening session on Friday morning, and the program was begun with the Johns-Manville film, "Underground Arteries." In his paper, "Centrifugal Pumps: Application and New Developments," H. A. Mylander discussed several types of water works pumps. O. C. Hopkins led a discussion dealing with the protection of distribution mains and outlined the U.S.P.H.S. requirements for protection of domestic water supplies. Joining in the discussion were E. A. Reinke and George W. Marx.

Judge Evo Deconcini of the Arizona State Supreme Court related some interesting facts on "Water Rates" at the Friday luncheon, comparing the various rates in effect in Arizona which range from a high of $3.00 per thousand gallons in one northern community where water is hauled from some distance, to a low of 5¢ per thousand in Yuma, where water is obtained from the Colorado River. He discussed the various factors governing the establishment of water rates and figuring of depreciation.

A.W.W.A. Vice-President W. Victor Weir led a discussion of methods of financing water and sewer main extensions. He was joined in the discussion by Richard Bennett, Clyde Mathews and H. H. Idle. Association activities in this field were emphasized by all who discussed the subject.

Toastmaster Byrl D. Phelps presided over the festive Friday banquet and presented Vice-President Weir who brought greetings to the assembly from the national organization. Jack J. Hinman Jr. gave an entertaining and humorous slide-illustrated talk entitled "Foulk's Law as Applied to Post-Curricular Achievement."

The erection of an elevated water sphere was the subject of a film presented by Chicago Bridge and Iron Company which opened the Saturday morning technical session. "Rehabilitation of the Yuma Water Works" was the subject of a paper by W. W. Williams. Recent additions and changes at Yuma have enabled the utility to double its capacity in two years. A panel discussion dealing with the problem of consumer complaints led by Col. Hinman concluded the morning session. Joining in the discussion were Dale Cox and John C. Luthin.

At the Saturday luncheon, A.W.W.A. director A. W. Miller reported the 1949 activities of A.W.W.A. and discussed the national board meeting

(*Continued on page 70*)

IT GOES IN FAST— IS MADE TO LAST

Experienced waterworks engineers and officials like Armco Steel Pipe for water supply and force mains because they get top efficiency in both installation and operation.

Long, easy-to-handle lengths, up to 50 feet, mean fewer sections to string—fewer joints to assemble. Standard and special fittings are prefabricated to save time and money in design and installation. The whole job moves faster, more economically.

Leakage is no problem because tight joints are obtained with field welding or any standard coupling. And Armco Pipe, unlike rigid material, flexes with the load to guard against explosive bursting due to vibration or sudden overload. A spun enamel lining prevents tuberculation and assures continued high flow capacity. Pumping costs are less.

Diameters of Armco Steel Pipe range from 6 to 36 inches; wall thicknesses from 9/64 to ½ inch. You'll save time and money by using Armco Welded Steel Pipe for that next water supply or force main. Write for booklet: "Design Standards for Steel Water Pipe." Armco Drainage & Metal Products, Inc., 1940 Curtis St., Middletown, Ohio.

ARMCO WELDED STEEL PIPE
MEETS AWWA SPECIFICATIONS

ARMCO

(Continued from page 68)

held in the spring. For the Arizona Section, A.W.W.A. Vice-President Weir presented Secretary Helen Rotthaus with a trophy cup for outstanding work as a section officer.

The Saturday business session featured a report of the Committee on Certification and Training. John A. Carollo, Chairman, reported that the committee recommended that a training program be initiated in 1950, to be developed under the guidance of the State Department of Health.

Under the direction of John C. Hoover, the Operators Roundup was held Saturday afternoon in parallel with the technical session. Problems of maintenance and operation were discussed informally at the Roundup. The afternoon technical session was opened with a discussion by Lester M. Louden on "Chemical Limits in Drinking Water Standards." Richard F. Poston discussed the Water Pollution Control Program under Public Law 845 and discussed the history of the law's enactment, its principal provisions, and the present status of the program. In his paper, "Naturally Filtered Water Through Induced Infiltration From Surface Water Bodies," Leland Glidden described the process of abstraction of naturally filtered water through induced infiltration from surface water bodies. "Use of Asphalt in Hydraulic Works," by J. M. Lackey, dealt with a description of the use of asphalt mixtures for lining reservoirs, canals and storm canals. The afternoon session was concluded with an abstract by George Marx of the afternoon's technical papers, for the benefit of the operators who had been in attendance at the Operators Roundup.

The traditionally informal Saturday banquet was presided over by Toastmaster A. W. Miller. Ray Smucker, manager of Yuma radio station KYUM, presented members of his staff in a hilarious variety show "broadcast" which took as its theme "Experimental Instrumentation of Public Relations." Station KYUM attracted nation-wide interest some months ago when it publicized the municipal water pressure variation as a guide to gaging the number of radio listeners dialed in to any given program. This theme was developed at the banquet program, with the pressure gage fluctuating wildly as various acts were presented. During the rites of the Select Society of Sanitary Sludge Shovelers, W. Victor Weir, O. V. Cooper, Jack J. Hinman Jr. and Ray Smucker were elevated to membership. 'Manufacturers' representatives were hosts at the dance which followed the banquet.

Under the direction of the Local Arrangements Committee, M. P. Goudy, Chairman, members and guests were conducted on a tour of the newly enlarged Yuma water treatment plant and the Morales Dam in Mexico. Mrs. Helene T. Bennett was in charge of the ladies' entertainment during the conference and the program included a bridge luncheon and a tea with Western entertainment.

HELEN ROTTHAUS
Secretary-Treasurer

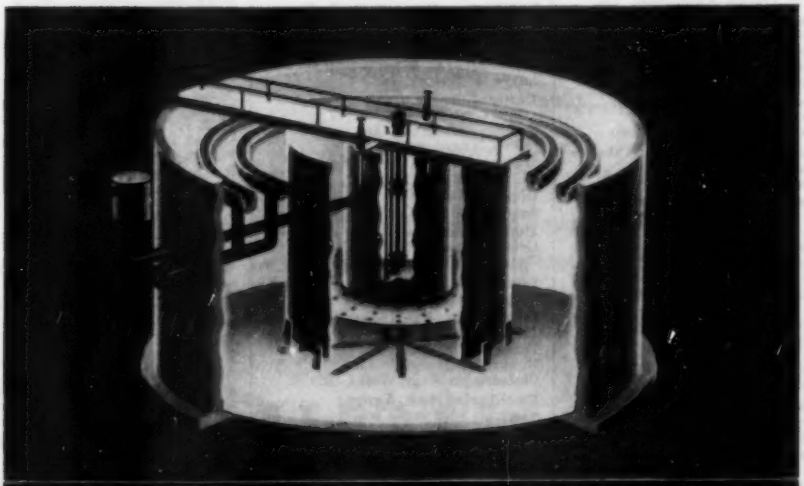
FOR WATER SOFTENING . . . TURBIDITY AND COLOR REMOVAL
. . . INDUSTRIAL WASTE TREATMENT . . .

The Clariflow

with independently-operated mixing, flocculation, stilling and sedimentation zones

A notable improvement over conventional short-retention water treatment units. Provides individual functioning of mixing, flocculation, stilling and sedimentation zones. • Its control over short-circuiting, control over each function and control of sedimentation through low weir rates mean improved effluent . . . higher filtration rates . . . longer filter runs . . . better industrial waste recovery and treatment.

Write for Bulletin 656



WALKER PROCESS EQUIPMENT INC.
FACTORY • ENGINEERING OFFICES • LABORATORIES
518 HANKES AVENUE, AURORA, ILLINOIS
PROQUIP

Index of Advertisers' Products

Acidizing of Water Wells:
Dowell Incorporated

Activated Carbon:
Industrial Chemical Sales Div.

Aerators (Air Diffusers):
Infilco, Inc.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Air-Lift Pumping Systems:
Worthington Pump & Mach. Corp.

Alum (Sulfate of Alumina):
American Cyanamid Co., Industrial Chemicals Div.
General Chemical Div.
Stuart Corp.

Ammonia, Anhydrous:
General Chemical Div.

Ammonia Receivers:
Worthington Pump & Mach. Corp.

Ammoniators:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.
A. P. Smith Mfg. Co.

Carbon Dioxide Generators:
Infilco, Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Dowell Incorporated (magnesium anodes)
Electro Rust-Proofing Corp.
Harco Corp., Rusta Restor Div.

Cement Mortar Lining:
Centriline Corp.
Warren Foundry & Pipe Corp.

Chemical Cleaning of Water Mains:
Dowell Incorporated

Chemical Feed Apparatus:
Belco Industrial Equipment Div., Inc.
Builders-Providence, Inc.
Everson Mfg. Corp.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Proportioneers, Inc.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.

Chemical Scale Removal Services:
Dowell Incorporated

Chemists and Engineers:
(See Prof. Services, pp. 24-27)

Chlorination Equipment:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine Comparators:
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine, Liquid:
Solvay Sales Div.
Wallace & Tiernan Co., Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Warren Foundry & Pipe Corp.

Clarifiers:
Chain Belt Co.
Dorr Co.
Graver Water Conditioning Co.
Infilco, Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Underground Pipe Cleaning Co.
National Water Main Cleaning Co.

Cocks, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Compressors, Portable:
Worthington Pump & Mach. Corp.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Fairbanks, Morse & Co.
Philadelphia Gear Works, Inc.

Dechlorinating Agent:
Virginia Smelting Co.

Diaphragms, Pump:
Dorr Co.
Proportioneers, Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 24-27)

Feed Water Treatment:
Calgon, Inc.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Infilco, Inc.
Northern Gravel Co.

Filters, Incl. Feed Water:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.
Walker Process Equipment, Inc.

Filtration Plant Equipment:
Builders-Providence, Inc.
Chain Belt Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Fish Screens:
Electric Fish Screen Co.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.

Fittings, Tees, Ells, etc.:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr Co.
Infilco, Inc.
Stuart Corp.
Walker Process Equipment, Inc.

Fluoride, Sodium:
Aluminum Co. of America, Chemicals Div.

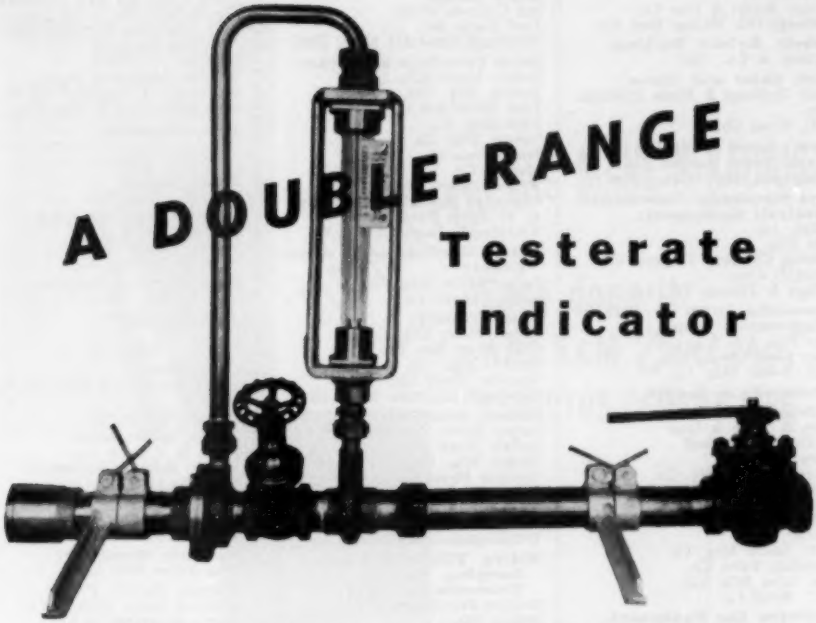
Furnaces:
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Furnaces, Joint Compound:
Northrop & Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc.
Infilco, Inc.
Northrop & Co., Inc.
Simplex Valve & Meter Co.
R. W. Sparling

A DOUBLE-RANGE Testerate Indicator



. . . you can take out on the job

WRITE FOR CATALOG 50

It contains full information about the Double Range Indicator and other valuable meter testing and setting equipment. FREE.

With this Portable Double Range Testerate Indicator you can field test meters at rates of flow anywhere between 1/4 g.p.m. and 175 g.p.m. Accuracy is within 2%. The value of the time saved is considerable. Each Indicator is equipped with lubricated plug valve, spring-loaded check valve and four adjustable supporting legs.

The **TESTERATE INDICATOR**

FOR BETTER WATER SERVICES

FORD

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana

Gasholders:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
Northrop & Co., Inc.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Goosenecks (with or without Corporation Stops):
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Greensand; *see* Zeolite

Hydrants:
James B. Clow & Sons
M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
John C. Kupferle Foundry Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Leak Detectors:
Goldak Co.
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Magnesium Anodes (Corrosion Control):
Dowell Incorporated

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe Locators:
Goldak Co.
Jos. G. Pollard Co., Inc.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.

Note the radius, with strictly standard pipe and couplings.

STRAIGHT LENGTHS MAKE A RADIUS

Easy does it with K&M *"Century"* ASBESTOS-CEMENT PIPE

Note the sure, simple, fast way to make tight joints for straight lines or radius.

5 DEGREE deflection at each pipe joint is perfectly safe and simple in laying K&M "Century" Asbestos-Cement Pipe with "Century" Simplex Couplings (made of identical material). Offsets may go to 13 inches per standard 13-foot pipe length. With shorter straight lengths even the sharpest practical radius is easy. Nothing special is needed.

Such simplicity underscores the economy of laying this K&M pipe—inexpensive to haul—light to handle—easy to cut on the site. Continued economy comes from high resistance to soil corrosion and immunity from tuberculation and electrolysis. The initial high flow capacity cannot be reduced by tuberculating waters.

Highly resistant to the stresses of traffic and earth settlement, as well as to chemical deterioration, K&M "Century" Pipe actually gains strength as it ages. It is recoverable for re-laying in its original pressure class! Here is low cost—lastingly. Write us for full data.

Nature made Asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages:
(See Gages)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

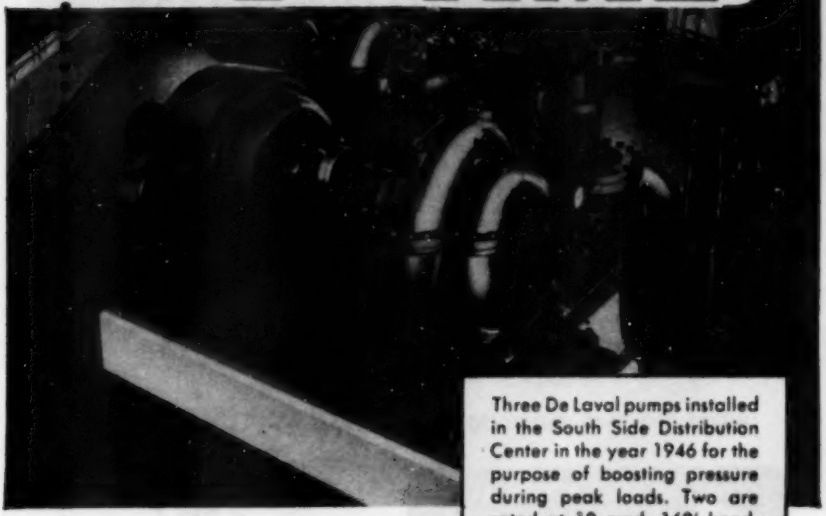
Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

FOR THE 7th TIME



Three De Laval pumps installed in the South Side Distribution Center in the year 1946 for the purpose of boosting pressure during peak loads. Two are rated at 10 mgd, 160′ head, the third at 15 mgd, 160′ head.

FLINT WILL INSTALL DE LAVAL PUMPS TO MEET INCREASED WATER DEMANDS

Seven times in a row . . . 1918, 1921, 1923, 1924, 1930, 1946, and now in 1949 the City of Flint, Michigan will install De Laval pumps to satisfy an ever increasing demand for water. Four low lift and two high lift pumps will be installed in Pumping Station No. 3 later this year and they will give the City of Flint a total capacity of 352 mgd . . . all handled by De Laval pumps.

Here, as in over 78 per cent of America's cities, De Laval pumps have insured complete dependability and high sustained efficiency, year after year. When you are ready to install additional pumping capacity, specify DE LAVAL.

Send for Catalog 10-8-JA

DE LAVAL

DE LAVAL STEAM TURBINE CO., TRENTON 2, N. J.

TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS AND COMPRESSORS
CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

WW-8

ARE YOU LOSING AN ADEQUATE WATER SUPPLY THROUGH NEEDLESS WASTE?

TO CONSERVE WATER . . . *METER ALL SERVICES*

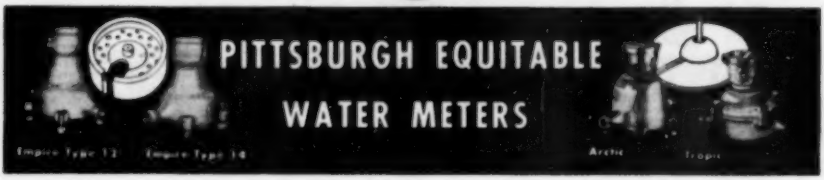
The nationwide water shortage has been widely publicized. Never before are so many people water-conscious. If your system is not 100 per cent metered you know that much water is being wasted. Now is the time to advocate metering to your consumers and municipal officials. You'll do yourself and the community a service. To help you "sell" this idea we have prepared a complete portfolio of factual data on how a community is benefited by metering all services. Write for it today — no obligation involved.

WRITE FOR THIS PORTFOLIO OF EDUCATIONAL AIDS

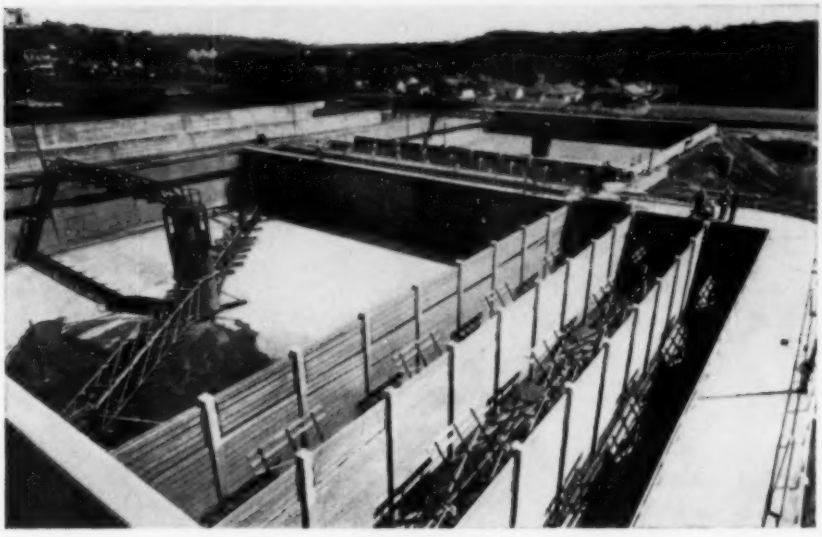
Pittsburgh Equitable Meter Division, ROCKWELL MANUFACTURING CO.

Pittsburgh 8, Pennsylvania

Atlanta Boston Chicago Columbus Houston Kansas City
Los Angeles New York Pittsburgh San Francisco Seattle Tulsa



THE DORRCO FLOCCULATOR AND THE DORRCO SQUAREX CLARIFIER + **STANDARD CHEMICALS** = **REAL SAVINGS FOR YOUR WATER TREATMENT PROJECT**



One of the primary advantages resulting from the use of the Dorrco Flocculator and Dorrco Squarex Clarifier in combination is that standard chemicals, such as alum and lime, may be used exclusively. In many cases, this results in a marked saving in operating costs as opposed to other types of water treatment units where expensive flocculating agents and close operating control are required. In numerous installations, Dorrco Flocculators have paid for themselves in a very few years by savings in chemicals and improved overall plant operation.

Also unique with the Dorrco Flocculator and Dorrco Squarex Clarifier is the substantial saving in first cost due to the inexpensive commonwall construction. The entire unit is cast in a single structure permitting a minimum of pipe lines and channels . . . and having a compact, attractive layout. Where multiple units are required, as in the above view of a recent Dorr installation, the tank shape is ideal.

$ **Let an experienced Dorr engineer show you how the Dorrco Flocculator-Squarex Clarifier team will go to work for you on a dollar-saving basis.**

DORR

RESEARCH ENGINEERING EQUIPMENT

DORRCO

THE DORR COMPANY, ENGINEERS
BARRY PLACE, STAMFORD, CONN.

NEW YORK • ATLANTA • TORONTO
CHICAGO • DENVER • LOS ANGELES

RESEARCH AND TESTING LABORATORIES
WESTPORT, CONN.

SUGAR PROCESSING
PETREE & DORR DIVISION, STAMFORD, CONN.

ASSOCIATES AND REPRESENTATIVES
Dorr Technical Services and Equipment Are Also Available Through Associated Companies and Representatives in the Principal Cities of the World. Names and Addresses on Request.

LEADITE

Trade Mark Registered U.S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking